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THE GLASS CONTAINER INDUSTRY

An Economic Study of Some Primary Factors in the Industry which Have an Important Bearing upon Its Future Destinies

By W. STANLEY RENDALL

AT THE present time the Glass Container Industry is facing the problem of deciding whether or not the provisions of the recently outlawed National Recovery Act and the Code of Fair Competition were effective in bringing about a condition of greater stability within the industry as a whole.

Upon what basis will this problem be considered? Has there been any significant improvement in the standard of living for labor, or in the number of people employed? Have shipments increased? Is capital investment more secure? Can earnings be considered reasonable?

At the time of its enactment there was little if any disagreement regarding the objective merit of the National Industrial Recovery Act or of the Code of Fair Competition for the Glass Container Industry. Majority opinion recognized the existence of an emergency situation and was willing to support the New Deal which, according to its sponsors, was basically intended to bring about a degree of control within narrower limits than had previously existed over those elements which contribute towards a well balanced political economy.

History has shown that the law of supply and demand ultimately controls the politico-economic structure and that abnormal fluctuations in this law have been the causes of so-called business cycles which have in turn brought about severe crises affecting all classes of society.

Basically a primary function of government is to direct broad general policy and in times of crisis it should properly assume executive authority, because the very nature of a crisis is indicative of the inability of individualism to properly regulate itself in relation to the social structure as a whole.

W. STANLEY RENDALL was trained as an engineer and physicist. He became interested in glass making through his work in the gas and chemical field and for several years he had connections with some of the largest European glass companies.
In 1926 Mr. Rendall joined the staff of the Hartford-Empire Company. In 1931 he organized the Economics Research Department of this company, which he had in charge until January 1st of this year when he became Manager of the Diamond Glass Company. He is exceptionally qualified to write with authority on economic problems connected with this industry.

It would seem to follow that the avoidance of crises is largely dependent upon competent analysis of each individual unit in the social-industrial structure, which means that the general policy of each individual concern should extend beyond its mere corporate responsibilities and become actively interested in the economic stability of the industry in which it is engaged.

The Glass Container Industry is no exception to this premise. Increasing mechanization, increased facilities for production, accelerated rate of obsolesence being but a few of the reasons which make it imperative for the industry to develop and utilize a broad concept of planning in the solution of its common problems.

Since 1898 the manufacture of glass containers has been revolutioned by the introduction of several mechanical processes differing from each other in certain fundamental respects.

1. From 1898 to 1905 semi-automatic machines requiring for their effective working skilled workmen, largely displaced hand blowers in the manufacture of wide mouth ware.

2. From 1905 to 1917 the automatic suction process was the chief factor in the displacement of hand blowers and of the skilled operators of semi-automatic machines. Contemporaneous with the introduction of the automatic suction process was the appearance of semi-automatic machines for making narrow neck ware.

3. From 1917 on, the trade was again revolutionized by the introduction of the "Flow Feed" device commonly called Feeder which, while requiring more labor per unit of production than the automatic suction machine, was nevertheless a radical advance over the semi-automatic machine process. Furthermore the Feeder permitted a maximum of flexibility, a factor of outstanding importance in

meeting the demand for glass containers, which increased from about 10 million gross in 1900 to over 30 million gross per year during the past few years.

Simultaneously with the development of machine processes was the improvement in other components for glass container manufacture.

In 1860 Sir William Siemens developed the principle of regeneration as applied to a Pot Furnace and in 1861 he developed the tank furnace for glass melting, the original furnace having only one compartment; but his next installation built in 1869 contained three compartments for melting, refining, and working respectively. It is interesting to note that present day furnaces consist of only two compartments, the melting end in which both melting and refining of the glass takes place, and the nose or working end.

Many years of operation of the Siemens type furnace has brought about certain established practices in design and operation resulting in greater stability of operation and in increased ratings until today 7½ sq. ft./ton/-24 hours is not an uncommon rating.

The Unit Type annealing lehr combined with automatic stacking has become substantially standard in the industry and several forming processes are available each of which represents an advanced use of engineering design and knowledge of the physical and working properties of glass.

The changes brought about by technological development have been paralleled by changes in the status of labor, the capital structure of the industry, and in methods of marketing.

1. In 1905 control of the industry largely resided in the hands of skilled labor requiring a minimum of investment in machinery and auxiliary equipment. This situation has completely changed during the past thirty years. Today this control is largely held by concerns owning legal monopoly in essential components of manufacture.

2. The period 1928-1932 was largely consumed in determining the rights of certain parties in the control of automatic glass feeding. This period can also be characterized by intense competition in the manufacture and sale of glass containers.

3. In August, 1933, the Glass Container Industry submitted a Code of Fair Competition to the President of the United States in accordance with the provisions of the National Industrial Recovery Act. This code included a number of factors denoting a desire on the part of the industry to develop a "planned economy" as evidenced by the quota plan of production and operating days, minimum wages and hours and "definition" of fair competition.

In studying the economic status of the industry it is interesting to note the several control factors which exist at the present time.

1. Patent Control of certain essential components in the manufacturing process to which can be coupled

2. License Control of manufacture by types of containers and quantities.

3. Until recently, legislative control by government on such questions as labor relations, wages and hours.

4. Voluntary Control by the association of individual manufacturers in a Code of Fair Competition on such questions as production, operating time and fair competition.

Another factor of great significance concerns the ability of the small and medium size concern to successfully compete against large scale organization, and the concentration of productive capacity in the hands of a relatively few concerns. In this connection approximately 10 per cent of total concerns control about 70 per cent of total productive capacity, which capacity is about 65 per cent in excess of the total requirements as measured by sales of glass containers during the past two or three years.

Keeping in mind that during the next few months a decision will have to be made regarding continuation of the present code or the drafting of a new code, or complete abandonment of the "planned economy" concept of industry, it would seem to be very desirable to carefully consider the main factors which enter the problem, and the detail composition of these factors in an attempt to measure the degree of economic interdependence of the individual concerns engaged in the industry and the need for voluntary self regulation supplemented by such mandatory regulations as seem desirable.

THE ECONOMIC PROBLEM

In its broadest terms the economic problem has three distinct but integral parts. It can be simply expressed something as follows:

1. The inevitability of technological advance.
2. The rights of labor in relation to technologocial advancement.
3. The rights of capital to reasonable earnings.

The analysis of the economic problem, in order to be practical and useful as a basis for formulating conclusions, must necessarily be based on reliable facts concerning all phases of the problem.

Unfortunately, and in spite of the opportunity afforded by the Code for the collection and assimilation of facts, these have largely been restricted to quantities of production, shipments, and stocks of finished ware.

Nowhere in the industry has a "measuring stick" been perfected to include the comparative performance of equipment and the character and incidence of production, the suitability and quality of the industry's production in relation to competing products, the characteristics of market, or finally a comparative basis of costs and earnings. It might also be stated that the industry as a whole is without a concerted labor policy as related to welfare and social security.

It is, of course, hardly conceivable that any real or lasting stability can be achieved so long as individual concerns in the industry are without any form of comprehensive "measuring stick" of the factors above mentioned, and the purpose of these series of articles is to present to the industry an outline of the economic problem and to analyze such facts as are available.

Mr. Rendall will continue his discussion of the economic problems of the container manufacturer in THE GLASS INDUSTRY for August. Do not miss any article in the series—it is the first time these problems have ever been competently analyzed and the facts that will be presented are vital to a proper understanding of the future.

CONFERENCE ON GLASS PROBLEMS

Complete Summary of Papers Read at Urbana

THE Third Conference on Glass Problems jointly sponsored by the Department of Ceramic Engineering of the University of Illinois and the Chicago Section of the American Ceramic Society opened on the afternoon of May 31. Sixty-nine men were registered, exclusive of a large local representation. Dean M. L. Enger of the College of Engineering welcomed the group on behalf of the University and spoke of the value of meetings such as this in bringing the practical into an academic atmosphere. The function of the Engineering Experiment Station in bringing industrial problems into the school laboratories with mutual advantage to industry and the teaching staff of the school was mentioned.

Professor C. W. Parmelee, Head of the Department of Ceramic Engineering, acting in his role of chairman, asked each present to arise and introduce himself. After this general introduction, the presentation of papers was begun.

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Report of Progress in Glass Research in the Department of Ceramic Engineering University of Illinois

By Professor C. W. Parmelee, University of Illinois

PROFESSOR PARMELEE presented an interesting report of the various investigations of interest to glass workers made in the Department laboratories during the past year. Some of these are still in progress. The general trend of the studies has been toward the effect of alumina on properties of glass, but other points have also received consideration. An abstract of the report follows with the names of the men who are carrying on the work.

Rate of Melting, *By W. B. Silverman*

Alumina is present in nearly every glass produced, either by accident, or intent. The effect of alumina on melting rate is of interest.

Previous investigators have reported contradictory findings on the effect of alumina on melting rate. If the fundamentals underlying the cause of disappearance of the final phase in melting are considered, the effect of temperature is largely one of effect on viscosity.

A soda-lime-magnesia-silica glass to which was added 0, 2, 4, and 8 per cent alumina, was used in the investigation. The tests were conducted by mixing the raw batch and calcining at 1000°C. The calcine was crushed and the final meltings carried out from 1200°C to 1400°C at 50° intervals. An increase of melting time is noted with additions of alumina, the greatest being with 2 per cent and further additions causing smaller increases.

As the temperature increases, the melting time decreases and there is practically no difference in time for melting of 4 and 8 per cent Al_2O_3 glasses above 1350°C.

The effect of temperature on viscosity may explain the decrease in time for melting with increase in temperature. The pronounced difference between 0 and 2 per cent may be due to change of the last crystalline

A group of conferees assembled in front of the Ceramics Building following the meeting sponsored by the University of Illinois. On the extreme left is Professor C. W. Parmalee, head of the Department of Ceramic Engineering.

phase present in the melt from wollastonite to tridymite and cristobalite.

Scratch Hardness of Glasses, *By K. C. Lyon*

THE scratching properties of glasses are worthy of consideration because of the effect of scratches upon beauty and strength of the various types of glassware. In this investigation the scratch hardness of glasses is being investigated by use of a sclerometer equipped with a diamond scratching point. The hardness is deduced by comparing the widths of the scratches made under a definite loading. Measurements are made with a microscope.

The numerical values for hardness of different glasses will be expressed in terms of the Moh's scale of hardness. This will be done by comparing the width of scratches on glass and appropriate minerals. All the glasses so far tested lie between apatite and feldspar, numbers five and six of the scale of hardness.

Early indications are that rouge polishing a plate glass softens its surface and that a rough-rolled plate glass and a fire-polished glass of the same composition have nearly the same hardness. The addition of alumina to a bottle glass makes it more difficult to scratch. A condensation product placed on the market as a glass substitute is more readily scratched than ordinary sealing wax. A number of other comparisons of scratch hardness will be made to complete the investigation.

Thermal Expansion of Glass, *By J. J. Theodore*

Measurements of thermal expansion on a soda-lime-magnesia-silica glass to which 0.8 per cent Al_2O_3 was added showed that alumina lowers thermal expansion and increases the annealing temperature of the glass studied. The interferometer was used in making the measurement.

The Meaning and Measurement of the Surface Tensions of Glass, *By C. G. Harman*

Surface tension forces enter into many glass forming processes—the shaping of blanks for molds, the smoothing of surfaces, the making of circular cane, and the difficulty of molding sharp edges are some examples. A high surface tension will slow up the planing of glass. Surface tension has an important role in refractory attack.

The phenomenon of surface tension is caused by a mutual attraction between molecules and a tendency for the molecule to be pulled into the body of the liquid. The greater the attraction, the higher the surface tension, and also density, strength, etc.

The method for measurement used was the maximum bubble pressure method (Jaeger method), previously adapted for measurements of surface tension of glass by Parmelee and Lyon. In this the pressure required to blow a bubble at the lower end of a tube immersed in a liquid and the diameter of the tip are factors in measurement. A platinum capillary is used in making measurements of glasses. Density data are also needed and were obtained by finding loss of weight of platinum ball immersed in molten glass. It was found that additions of alumina raised the surface tension of the soda-lime-magnesia-silica glass studied. Values lie in the range of 295-340 dynes per cm. in the temperature region 1250 to 1400°C.

Tensile Strength of Glass, *By A. E. Badger and W. B. Silverman*

Tensile strength is important in structural glass and in glasses where thermal resistance is necessary. The poor agreement of results of tensile strength measurements of previous investigators is due to the effect of rate of loading, shape of sample, size of fiber used, surface condition, and eccentricity of loading due to brittleness.

In this investigation tests are being made on glass fibers which are first "necked down" to ensure breakage near the middle of the specimen instead of in the holding chucks. A loading mechanism using mercury has been devised. This gives a smooth, steady rate of loading which can be duplicated.

Results from this research are too incomplete to permit reporting at this time.

Melts of High-Alumina Glasses, *By W. S. Debenham*

Experimental glass batches were made up to contain soda and potash to 20 per cent, lime and magnesia to 30 per cent, boric acid to 30 per cent, Al_2O_3 to 25 per cent, and silica 50 to 80 per cent. The ratio of lime to magnesia was 7:2, by weight. The batches were mixed and heated in small pots to 1420°C. After cooling, the glasses were examined for completeness of melting and appearance. Thermal expansion measurements from room temperature to 100°C were made by use of an arrangement fitted with an Ames dial.

It was found that at least 15 per cent lime-magnesia were necessary to produce clear glasses when the alumina content is greater than 12 per cent, regardless of alkali present. As high as 22 per cent Al_2O_3 could be used in clear glasses with 15 per cent lime-magnesia. For opalescent glasses, B_2O_3 should not fall below 5 per cent or Al_2O_3 or alkali be over 12 per cent. Increasing boric oxide content increases opalescence.

The whole field of glasses studied had low thermal expansion characteristics.

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Cullet

(Editor's Note: This combines Dr. C. J. Uhrmann's paper on "The Use of Cullet in the Glass Industry," a summary of a questionnaire on the use of cullet, and the general discussion on cullet.)

THE name "cullet" commonly refers to broken glass obtained either from waste in manufacture or from the consumer, directly or through agents. For reasons of economy, glass cullet is used in almost all commercial glass batches. The amount used varies widely, running as high as 100 per cent in some cases, but the general preference seems to be within the limits of 25 to 60 per cent. The amount of cullet used frequently depends on the amount available. Hand-working may provide 50 to 60 per cent cullet for the batch, while machine working usually has 20 per cent, half of which may be secured from the outside, but preferably from glass of the manufacturer's own making.

The storage of cullet presents a problem since contamination of cullet by tramp metal, dust and other foreign substances is a frequent source of trouble. It is sometimes said that cullet is the hardest material in the glass plant to keep clean. For most satisfactory results, it seems to be a good practice to move the cullet as fast as possible. In one plant, the cullet is

stored for only two days at the most. The result is that the material is kept clean and is re-used before the molten glass composition has changed much. This decreases the chance of inhomogeneities arising from the use of cullet of different composition than that of the resulting glass such as might occur if the glass changed gradually and cullet were stored for some time. When there is danger of contamination of the batch from the cullet, it should be magnetically separated, washed, and dried before using.

Cullet is usually crushed before being added to the batch. Usually ½" to 1" mesh size is satisfactory, although smaller sizes have been used. When cullet is used in large lumps, difficulties are likely to arise from inhomogeneity. In one plant where pressed ware was being made from a pot furnace, the glass sticking to the pontils was thrown into the batch. Conditions grew worse and worse until the breakage of the ware reached 60 per cent. The only reason for the high breakage that could be found was the manner of disposing of the cullet. When the amount of cullet from this source was reduced, the amount of breakage fell to about 1 per cent. In this case, the extreme brittleness was thought to be due to inhomogeneity.

WHEN cullet is carefully weighed out and added to batches at the mixer, uniform distribution is assured and the occurrence of inhomogeneous melts is avoided. The use of wet cullet is likely to cause trouble. When it is added to the batch at the mixer, the tendency is for the soda to cling to the wet surfaces instead of mixing uniformly. Since it is the sand which most needs the fluxing effect of the soda, this retention by the cullet is a detriment to the melting. It seems to be the general opinion that the use of wet batches tends to produce seedy glass, although the use of water in a batch may have some definite, valuable influence on the properties of the glass. The use of a dampened batch reduces the amount of dust in the furnace, but the amount of water used varies widely in practice. It was stated that in Europe, it was frequently the practice in pot melting to use a moist batch for some glasses and a dry batch for other compositions.

Close control of cullet is necessary and it should be used in the same way as other raw materials, with consideration for its chemical composition. While a manufacturer can be fairly sure of the cullet produced in his own plant, that obtained from outside sources must be classified and its composition determined before it is used. The best and cleanest cullet is that which is obtained by draining pots and tanks into water. This material is broken up into conveniently sized pieces. Cullet from machine operation is fairly clean, but cullet from hand working is quite likely to be contaminated with iron scale and coloring materials. In making cased glass, the effect of the use of variable amounts of foreign cullet is noticeable in the expansion conduct.

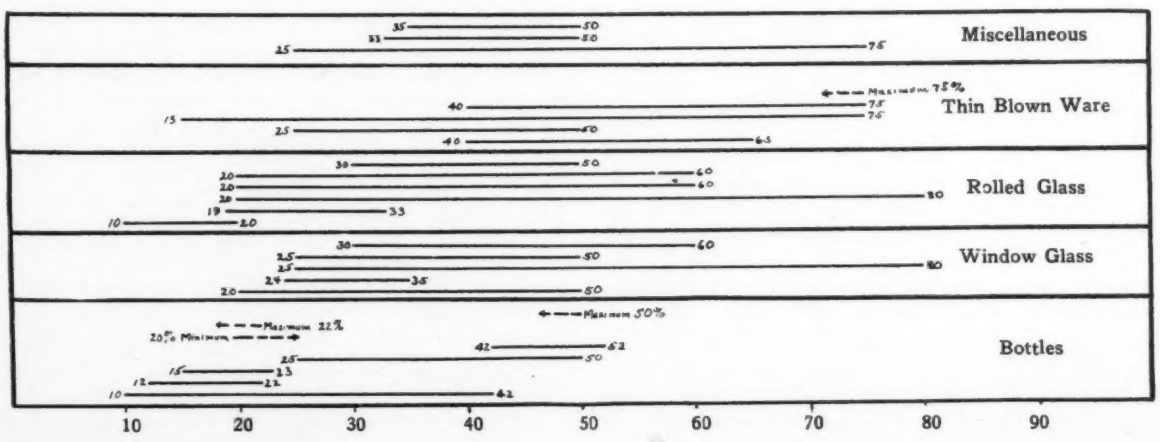
One question asked in the questionnaire: "Do you consider it advisable to increase the amount of alkali in the batch if the cullet to batch rate is increased?" brought 30 replies. Of these, only six advised an increase in alkali. One manufacturer increases the alkali by 5 pounds (per 1,000 lb. of sand) when the cullet is raised 15 per cent. It appears that the other five manufacturers who favored an increase in alkali made the addition in small and increasing amounts until the desired working properties of the glass were obtained. Two replies stated that a higher working temperature was necessary when the cullet was increased, and this higher temperature compensated for the lower alkali content of the glass.

The relative thermal expansions of two glasses used in making cased ware may be quickly found. A cased glass cylinder of about four inches in diameter is blown and quickly annealed. After the annealing, rings of about one-inch breadth are cracked off and split. The agreement of expansion of the glasses is shown by the behavior of the glass in drawing together or pulling apart at the split. This is a very satisfactory factory test.

When cullet is used in the batch, difficulty with refining may be expected due to an increase in viscosity. It is the usual practice to increase the working temperature of the glass to overcome the effect of increased viscosity. Some manufacturers make a practice of adding more alkali to the batch to preserve the original viscosity at the same temperature when cullet is used.

Although cullet is widely used in the glass industry and there are general observations on its effect on the working properties of glasses, a study of its action would make a problem for fruitful research.

PERCENTAGE OF CULLET IN THE BATCH
(Range in Use, or Range Considered Advisable)



Application of Special Refractories in Glass Furnaces

By M. C. Booze, Chas. Taylor Sons Co., Cincinnati, Ohio

MR. BOOZE pointed out that the tendency to increase melting rates of glass furnaces has brought about the need for improved refractories. He stated that his experience with "super" refractories was confined to the blocks made by his company from Indian cyanite. This material has an advantage over domestic cyanite in that it retains strength after calcining and can be used where control of grain size is important.

After the material is calcined, it is crushed, ground, and molded. Different methods of preparation result in products of differing degrees of density. The materials of lesser density are used where floating parts are needed. Due to the presence of free corundum in the raw material, the product is higher in alumina than the theoretical composition. The iron content is about 0.61 per cent and most of this is introduced in the grinding of the calcine.

The product has good strength at high temperatures and can be used where silica brick are commonly used at present. It is more dense than silica brick and shows no observable reaction with alkali dusts. The alkalies do condense on the surface, but drip off without a great amount of penetration. The alkali slag dripping from silica brick will attack the cyanite refractories.

In addition to its use as a substitute for silica parts, the product is used for feeder parts and the like. Users of the material differ in opinion but a conservative observation would be that the material cannot withstand thermal shock quite as well as fire-clay refractory material, and so the careful pre-heating of parts to be used in plunger replacements, etc., is necessary.

It is reported that hot repairs are made more easily with the cyanite material than with fire-clay. One factory makes a practice of coating the piece with molasses before insertion into the furnace. It is believed that the molasses leaves a carbon deposit which reduces the thermal shock given to the piece.

The material was described very conservatively and Mr. Booze was able to show by illustration some of the advantages of his product over competing materials.

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Heating-up a Glass Tank Furnace

By Z. C. Kline, Niles Glass Works of General Electric Co., Niles, Ohio

MR. KLINE'S paper presented a schedule for heating up a glass tank, with a description of the methods used in controlling the operation. The paper is reproduced in full and will be found on page 209.

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AT THE evening session of the glass conference, Professor A. R. Cahn, of the Zoology Department of the University, gave a very interesting and instructive lecture entitled "The Land of the Midnight Sun." Dr. Cahn illustrated his talk by motion pictures in color taken when he visited Norway last summer.

Mr. G. G. Hanson, Chairman of the Chicago Section, American Ceramic Society, presided over the Saturday morning session of the Conference. This session was devoted to consideration of various aspects of insulation.

Summary of Questionnaire on Insulation

THE SUCCESSFUL use of insulation in the open-hearth steel furnace suggests application to glass furnaces which are similar in construction, especially since these show a thermal efficiency of only 20 per cent at best.

While about 50 replies to the questionnaire sent out by the Department of Ceramic Engineering were received, the omission of some answers made an average of about 30 replies to each question.

The majority of the opinions were against insulation of the melting end crown because of the severe conditions. They favored insulation of refining end crown, but many affirmative replies lacked enthusiasm. The general opinion was strongly against insulation of melting end flux blocks. Most replies favored insulation of refining end flux blocks. Melting end bottom —no. Refining end bottom 2 to 1—no. General approval of insulation of all parts of regenerators was found. Replies were mostly in favor of uptake insulation and against insulation of port walls. Recuperator wall insulation unanimously agreed upon.

The question asking what parts of glass tanks have been insulated and opinion of results obtained, showed a wide variety in answers. A number were as follows: Refining end blocks ran red hot when insulated, better glass was made without. Flux blocks and bottoms insulated gave poor glass. Insulation of refining end crowns showed some fuel saving. It is practical to insulate the refining end of a tank. Melting end crown showed shortened life when insulated. Many insulated regenerators were reported as operating successfully.

Is insulation of refining end an aid to homogeneity of glass? It helps to eliminate channeling. It aids if the feed is shallow. Another opinion was that if the glass is properly melted, it retains homogeneity in refining end. There were many negatives—increased corrosion especially at joints decreased homogeneity. It is said to prevent collection of heavy glass, which holds iron and clay, in the bottom of the refining end.

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The Principles of Heat Transmission and Insulation of Furnace Walls

By Professor R. K. Hursh, Dept. of Ceramic Engineering, University of Illinois

IN PRESENTING this paper, Professor Hursh pointed out that, in general, there were three conditions of heat transfer in furnaces: (1) Steady temperature as in continuous furnace operation; (2) Changing temperature as in heating or cooling the furnace; (3) Cyclic temperature changes as an alternate heating or cooling the regenerator chambers. In any of these cases, any of

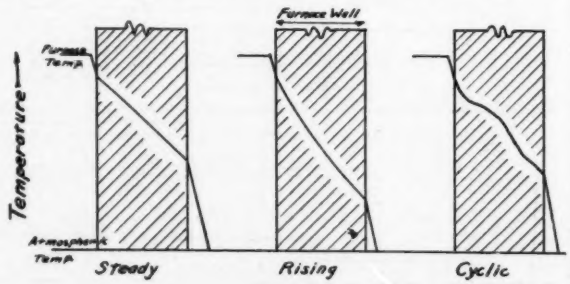


Fig. 1

the three methods of heat transfer may be involved. These methods are: (1) Conduction, heat transfer by direct contact; (2) Convection, heat transfer by means of a fluid; (3) Radiation, heat transfer by radiation through space.

The temperature conditions in a furnace wall under any of the three heating conditions are illustrated in Figure 1. The sharp drop at the surface is due to a surface film which resists heat transfer. The film becomes less effective with increase of velocity of gases passing the surface. The loss of heat from a furnace wall is due to both radiation and convection. An overall factor usually assumed for the film effect is 2.5 B.T.U. per sq. ft. per hour per deg. Fahr. in still air. With an increase in surface temperature, there is a rapid rise in the amount of heat lost.

THE accurate calculation of thermal conductivity is almost out of the question because of the lack of suitable data. The actual calculation of heat flow through a furnace wall under steady conditions is a simple matter, but with variable temperatures at either surface or in the wall, as in the heating-up period, or in cyclic operation, a complicated mathematical analysis is involved.

Insulating materials are of two types: (1) backing-up for outside walls, and (2) refractory insulation used as a lining. Refractory insulation is out of the question for most glass furnace equipment because of corrosive conditions due to dust and vapors in the gases. The purpose of insulation is to reduce heat flow. Figure 2 shows how the use of insulation gives a greater temperature drop through a wall as a whole, indicating an added resistance to the flow of heat. Because insulating materials have a lower heat conductivity than either fireclay or silica, the advantage in decreasing heat loss is evident. Insulating materials also have a lower heat capacity than the refractories. Even though the average wall temperature may be increased by application of insulation, the net effect of its use is to decrease the amount of heat stored. Because less heat is absorbed, quicker heating of the furnace is possible.

The use of insulation will cause the average temperature of the refractory to rise even though the furnace temperature is not changed. This rise in wall temperature may bring somewhat greater danger of damage to the refractory.

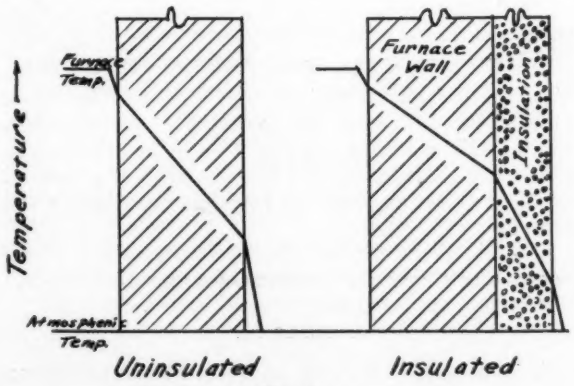


Fig. 2

Considerations in Applying Insulation

R. S. Moore, Harbison-Walker Refractories Co., Pittsburgh, Pa.

THE PREDICTION of thermal economy must rest upon cumbersome calculations based on data of low accuracy. However, it is possible to calculate the relative economies of different constructions. Assuming a nine-inch fire brick wall with a constant hot face temperature of 2100°F., for example, a calculation shows a reduction of heat loss from 1570 to 660 B.T.U. per sq. ft. per hour with the application of a 2½-inch diatomaceous earth brick insulation. A nine-inch insulation would further reduce the loss to 270 B.T.U.. The cost of the insulation must be considered along with the heat saving and it must be remembered that each additional layer of insulation reduces heat loss less than the previous one.

In some types of installation, heat capacity of the structure is of value. In intermittently operated furnaces, an appreciable amount of heat may be absorbed in the structure and lost. The use of insulating refractories instead of flint fire-clay bricks reduces the heat capacity of the structure by about one-third as well as adding insulating value. Insulating refractories are limited in application to locations where abrasion and corrosion are little. The coating of such brick with a mortar of the same thermal expansion properties will improve their life.

Temperature is the principal limitation to the use of insulating materials. Diatomaceous earth is among the most efficient of insulators from 900° to 1600°F. The shrinkage which sets in above this range harms the reclaim value. If the material has been previously calcined, it can be used up to the calcining temperature without further shrinkage. It is usually safer to reduce the thickness of insulation where temperatures appreciably above 2000°F are found at the interface between refractory and insulator. Where high interface temperatures are expected, a light weight refractory should be placed next to the furnace wall and insulation placed outside of that. In calculating interface temperatures, it is necessary to consider that there will be a rise when the furnace wall gets thinner from wear.

In some installations, the effect of insulation in increasing the temperature of the outside face of the refractory has not been taken into account. Failure of the refractory from softening under load due to increased temperature throughout the body may be avoided by using a material of higher grade. If heat input is not reduced after insulation is applied, failure of refractories may be expected. It is possible to operate a furnace so that the inner face temperature is no greater after insulation than before.

Where silica brick are used in sprung arches, the greatest compression occurs near the hot face which has undergone the most expansion. The application of insulation results in more uniform temperature throughout the arch and a better distribution of stresses. Improved life of steel furnace arches has been attributed to this action.

A light weight silica brick is recommended for insulation of furnace crowns. It being of the same composition as the crown, there is no reaction between the two, and if volatile fluxes get in it and cause slagging, the drips do not discolor the melt.

INTERNATIONAL 40 HOUR WEEK FOR ALL GLASS INDUSTRIES?

An international 40 hour week in the glass industries was recently voted by the International Labor Organization, meeting at Geneva. The government and labor representatives of 48 participating nations approved, but of employer representatives, only the United States and Italy voted affirmatively. The treaty will be submitted to each of the several nations for ratification; but the contention was made that the United States had no power to enter into any such engagement by virtue of the recent Supreme Court decision.

Hartford Empire Company has filed suit against the Florida Glass Manufacturing Co., Jacksonville, claiming infringement of its feeder patent 1,655,391. The United States District Court has granted a temporary injunction against the glass company.

NEW TARIFF RULING

A decision just handed down by the United States Court of Customs and Patent Appeals has the effect of reducing the tariff on importations of empty perfume bottles packed in boxes. Collectors of customs have held in the past that when empty bottles are imported in boxes the tariff applicable to the glass containers also applies to the boxes. Coty Processing Company, Inc., appealed from this ruling, but the District Customs Court overruled the protest. The dispute was then carried to the appeals court and Coty's contention that the boxes must be assessed at the lower duty fixed for such containers, was upheld. This rules out the policy of assessments "as entireties."

Production of refractories used for glass-house tank blocks, melting pots, stoppers, floaters and rings, amounted to 25,203 tons in 1934, compared with 22,065 tons in 1933. Stocks on hand last December 31, however, were slightly below a year ago for the same items, amounting to 19,535 tons, compared with 19,607 tons. The above data was released on May 22 by the Bureau of the Census as a preliminary report, and the final figures are subject to adjustment—usually negligible.

OCCIDENTAL LABOR BATTLES FOR SUPREMACY

Unless Occidental labor is utilized in a manner far more efficient than generally prevails today, even in the United States, the Western nations will be unable to compete with Oriental labor and management, according to Dean F. W. Shumard of the National School of Time Study, Norwalk, Conn.

"It is not generally realized that the Orient has just about caught up with us in the matter of automatic machinery and labor-saving technique," states Dean Shumard. "A dozen or more years ago, when cheap Oriental labor worked with a minimum of machinery and with little or no attempt at time study analysis, our American labor had little to fear. For the latter had splendid automatic machinery, the most efficient plant layouts, and capable direction to the end that efforts would count for the most production at least cost. But that was a dozen or more years ago.

"Of late we have been amazed at the rapid progress of Oriental industries. Particularly in Japan, the increase in labor-saving equipment is astounding. Our machinery purveyors have sold the Orientals anything and everything they wished, so that in labor-saving facilities many Oriental plants are on a par with our own."

JERSEY CERAMISTS MEET

Over two hundred attended the annual meeting of the Ceramic Association of New Jersey, held at Bridgeton, N. J., on June 14 and 15. It was one of the largest gatherings in the Society's history, and probably the most successful from every standpoint.

Members and guests assembled for registration Friday noon at the Elks' Club, Vineland, where a buffet lunch was served by Kimble Glass Company. V. V. Kelsey, Consolidated Feldspar Company, acted as toastmaster extraordinary and master of ceremonies.

During the afternoon visitations were made to several important glass factories in the locality. At the Kimble plant, the whole process of making tubing was open for inspection, as well as departments making laboratory and chemical apparatus. In the neighboring town of Millville, the immaculate plant of the T. C. Wheaton Company was specially noteworthy for its decorating department, and the Whitall Tatum factory as an example of efficiency in both management and methods.

Hamilton Fish, Jr., Congressman from New York State, was the principal speaker at the banquet, which was followed by a dance. At both of these functions, members were the guests of the glass industries and affiliated industries.

On Saturday the crowd split up. Many went on an all day fishing trip on Delaware Bay. A few foursomes of golf enthusiasts tried their luck at the Cohansik Country Club. Another group, not so frivolous minded, visited the quarries of the Tavern Rock Sand Company at Millville and the celebrated Seabrook Farms at Bridgeton.

Special asbestos suits that will permit men to enter flames with immunity are being manufactured and used in England. It is reported that these suits have been tested under the most dangerous conditions, the wearers even having entered blazing furnaces and worked there for some time.

ATWATER KENT WILL USE METAL TUBES

The Atwater Kent organization, of Philadelphia, one of the largest independent radio-receiving set manufacturers, will use the new metal vacuum tubes in its 1936 models. Mr. Kent himself made this announcement at a national conference of his distributors held in Philadelphia last month.

The distributors voted almost unanimously in favor of the Kent decision and reported the public already had begun to inquire for the new development.

W. Braun Co., New York, jobbers of glass containers, have moved their offices to 2433 West 14th Street.

INSULATION OF HIGH TEMPERATURE FURNACES

By R. S. BARBER
Johns-Manville

GENERALLY speaking, the advantages and economies resulting through the use of insulation on the exposed surfaces of industrial furnace settings are well recognized. With radiation losses in the cases of uninsulated settings amounting to from 8 to 15 per cent of the total heat input, it is apparent that there are attractive possibilities in the reducing of production costs by conserving even a portion of this heat which is otherwise dissipated to the surrounding atmosphere. Also as radiation losses increase rapidly with rises in temperature, the higher the furnace temperature the more attractive is this possibility of heat saving. For example, in the case of a furnace operating at 2000 degrees F., the heat loss through a 13½ inch firebrick wall into still air at 80 degrees F., is 995 B.T.U.'s per square foot per hour, while if the furnace temperature were 2700 degrees the loss would be 1520 B.T.U.'s or 53 per cent more. In the latter case, a reduction of the temperature of the outside surface of the wall by as much as 100 degrees would reduce the radiation loss by over one third.

Naturally the operating temperature as well as other factors affect the type, character and thickness of insulation which is suitable for a particular furnace. This is especially true in the case of melting or processing furnaces where the selection of an insulation should be made only after a study of the particular refractory conditions. Such a study will result in the narrowing down of the list of suitable insulations to a comparatively few. The material should have a fusion point well above the maximum temperature to which its hot face will be subjected; should retain its effectiveness over a reasonable period of time; should preferably be reclaimable; and should be of such a character as to not react with or otherwise have a deteriorating effect on the refractory. Experience appears to be proving that the raising of the mean temperature in a refractory lining by backing it up with insulation does not have a harmful effect providing that the maximum temperature on the hot face of the refractory is not increased. An insulated furnace operating at highly elevated temperatures necessarily must be closely watched and controlled and it is undoubtedly the absence of this precautionary measure which aggravated, if it actually did not cause, some of the early failures of insulated crowns.

The belief that the use of insulation would shorten the life of the refractory was for a long time held by many operators of open hearth steel furnaces. The experience of the last two years has disproved this theory and in their particular case the life of the roof over the bath has been extended rather than shortened. As a result, the practicability of insulating the roofs as well as the walls of open hearth furnaces above the charging floor is generally accepted throughout the industry.

Assuming that for a particular set of conditions several kinds of insulation are found to be suitable in the matters of temperature resistance, durability, adaptability, weight and structural strength, a decision then may properly be arrived at by considering the matter from an economic standpoint; i. e., jointly considering thermal efficiency and first cost. For example; if, in order to save a million B.T.U.'s in a month's time, one specification costs twice as much as another, the less expensive specification would obviously be the logical selection assuming that the two would have somewhere near the same length of life. On the other hand, if one specification costs twice as much as another but due to its better insulating properties, saves enough additional heat to show a high return on the added investment, the more expensive specification may show a lesser cost for saving a specified amount of heat. An inexpensive insulation does not necessarily mean an economical means of conserving heat and first cost should be considered only in conjunction with thermal efficiency and length of life.

The same line of reasoning can be followed in arriving at the economical thickness of an insulation. Each succeeding increment in the thickness of an insulation saves less additional heat and it is a relatively simple matter to determine the point beyond which the value of the additional heat saved will not show a satisfactory return on the added investment. The use of electricity or other high cost fuels justify thicknesses greater than where cheaper fuels are employed, and the same is true where furnaces operate continuously as compared to periodic operation.

In the insulation of arches and crowns of high temperature furnaces where operating temperatures approach the fusion point of the refractories, it is evident that the matter should be treated in a very conservative manner. The use of insulation results in more of the heat being retained in the furnace and unless this is compensated for by reducing the fuel input, excessive temperatures are apt to result on the hot face of the refractory. As previously mentioned, it is believed that some of the early failures of insulated arches were due to not taking proper cognizance of that fact. Adequate control equipment and careful operators should largely obviate this danger. Due to expansion which occurs in arches under high temperature, a bulk or semi-loose material is preferred by some, for as a class they conform to the movements better than a rigid material. By themselves, they do not, however, form a gas or an air seal; and if sufficiently porous, heat loss may result by convection currents through the material. A skim coat of cement or bonding solution is sometimes trowelled or sprayed on the surface to minimize this possibility.

BULK density as it affects dead load on a crown is a matter which should also receive consideration. In this respect loose materials generally have the advantage. Materials with densities as low as six pounds per cubic foot have been successfully used. Of first importance also, particularly in the case of melting furnaces, is that the material should be of such a character as regards chemical composition and fusing temperature that it will preclude the possibility of its contaminating the bath either directly or through fluxing with the refrac-

tory. This contingency can be partially guarded against by installing the insulation in a sufficiently small thickness to insure the maximum temperature on its hot face being safely below its softening temperature.

For side walls and bottoms, rigid or semi-rigid materials as typified by blocks and bricks have some natural advantages due to their structural properties. Calcined bricks due to their higher compressive strength have greater load bearing capacity under furnace bases and lend themselves well to veneer construction particularly when used in connection with standard firebrick refractory shapes. Insulating concretes being strong in compression are also used under hearths and bases and have had a wide application for bases installed underground.

IN MANY cases block insulation can be used to advantage and when finished off with a casting or cement plaster, result in an efficient and airtight construction. Blocks can be furnished in thicknesses of from 1 to 4 inches in increments of one-half inch, and due to their large size result in fewer joints. The use of two-layer construction installed with the joints staggered further minimizes joint loss and also permits of using combination specifications in which the inner layer of high temperature block is of a sufficient thickness to reduce the temperature to a point where the outer layer can be of a less expensive and at the same time a more efficient type.

In glass plants, insulation has been quite generally used in connection with regenerators, uptakes, flues, pot arches and annealing furnaces and lehrs, and consistently beneficial results obtained through saving in fuel, reducing joint leakage and improved operation due to better control and distribution of heat. The insulation of the melting furnaces proper has been the exception rather than the rule and for years the feasibility of attempting to insulate these furnaces has been a point of controversy among plant operators.

While it is generally agreed that much useful heat is dissipated through excessive radiation losses from uninsulated glass tank furnaces, the conserving of a portion of this heat is of secondary importance when compared with the possibility of contaminating a batch or shortening the life of the refractories. Insulation is of value only if it can be used without jeopardizing the successful operation of the furnace. Attempts up to the present in this direction have met with varying degrees of success and just what the ultimate solution will be remains to be seen.

While the operation of glass tanks and open hearth steel furnaces are not analogous, the experience obtained in the case of the latter may be of value in considering possible materials for glass furnace crowns. Two materials which have been widely used to date in the insulation of open hearth roofs are diatomaceous earth and expanded mica. The former is practically pure silica, having a melting point of 2930 degrees F. as determined by the U. S. Bureau of Standards and is ordinarily used as a coarse powder with a density averaging 20 pounds per cubic foot. Dusting may be minimized by introducing a light bonding agent. The expanded mica is also a form of silica having a softening point of approximately 2360 degrees F. and for industrial applications is usually furnished mixed with some asbestos fibre and clay so that with the addition of water it forms a highly adhesive cement. In this form the material weighs approximately 15 pounds per cubic foot and softens around 2240 degrees. Under the influence of heat the cement takes a hard set permitting of a bridging action which may be considered an advantage. In using either of the above or any other material on a crown, it would be advisable to apply only a thin layer, say 1"-1½" which would insure the junction temperature remaining well under the softening temperature of the insulation. After careful observation as to the effects on the refractory and on the operation of the furnace, the thickness of the insulation might later be increased.

In the matter of insulating the tank blocks on the bottom and sides, a similar procedure might be followed with a thin layer of high temperature block or brick insulation being installed behind the refractory and held in place with a casing or other mechanical means. To minimize the possibility of any tank leakage, the thickness of the insulation could be restricted to that which would result in the temperature on the cooler face of the refractory being below the freezing temperature of the batch. An insulation of 1" to 1½" on crown or tank blocks should reduce the radiation losses from those surfaces by about one-half.

As compared to continuous tanks, the possibility of ill-effects through the use of insulation should be less pronounced in the case of pot type melting furnaces and day tanks. With the periodic operation characteristic of the latter type of furnace, it is doubtful whether the maximum temperature gradient through the refractory is ever reached. In addition to fuel saving, the use of insulation should also result in a more uniform distribution of heat with a consequent improvement in the quality of the batch.

With the incentive which the use of insulation offers, as a means of reducing manufacturing costs, it is to be hoped that the problem will have an early solution. Improvements have been made in refractories and through conservative trials of carefully selected insulating materials, it is not beyond belief that a practicable as well as a safe means of securing the benefits and economies from insulation, may be realized.

●

In the discussion which followed Mr. Barber's presentation, the difficulty with insulated glass furnace crowns opening up and letting fire through was described. It seems that this is a common difficulty where insulated crowns have been used. The point that perhaps the problem of crown insulation had not received proper engineering analysis was brought out.

BUREAU OF MINES TO START MANY NEW PROJECTS

An appropriation of nearly $2,000,000 will permit the Bureau of Mines to greatly expand its activities during the new fiscal year beginning July 1. Among the new projects to be undertaken will be an investigation of the health hazards in the mineral industries, including harmful dust and gas diseases contracted by miners. Another project will be the study of low-temperature carbonization of coal, in the effort to find a solution of the smokeless fuel problem and to prevent waste of fuel values. Factual information will also be gathered with respect to the production, storage and utilization of petroleum and natural gas.

THE EYES HAVE IT

A Pictorial Presentation of the Manufacture of Artificial Glass Eyes

1

The first step is to hold a hollow glass tube over a flame and melt off a portion of the tube.

2

The small piece of tubing is then blown into the shape of an eye. Needless to say, great skill is required of the glass worker.

3

The colored enamel for the Iris is applied over a slow flame.

4

The eyeball is delicately broken loose from its stem. The back is now ready to be finished and smoothed so that it will rest comfortably in the eye socket.

5

A drawer of finished eyes, which will be carefully sorted as to size and coloring. Very perfect matching can be secured from stock selections but often the colorings are made-to-order.

ACCIDENT RATES IN THE GLASS INDUSTRY

The glass industry ranks eighth in frequency and tenth in severity of accidents on the basis of 1934 figures, in a list of 30 major industries, according to figures just released by the National Safety Council. These figures are based on reports from 43 glass plants, whose employees worked 50,079,000 man-hours.

In taking these places, glass plants averaged 9.84 for frequency rate, as compared with 15.29 for the 30 industries, while the corresponding severity rates were 1.04, against 1.70. The frequency rate is based on the number of disabling injuries per one million man-hours worked, while the severity rate is determined by the number of days lost as a result of disabling injuries, per 1,000 man-hours of work.

Since 1929, the glass industry has not done quite so well as industry as a whole in combatting accidents, the figures show. The frequency of disabling injuries has decreased 40 per cent, as compared with 42 per cent for all industries, while the severity rate for the glass industry has increased two per cent, in contrast to a decrease of 25 per cent for all industries.

The glass industry's 1934 frequency rate is nine per cent higher than that of 1933, and the severity, 96 per cent higher. These changes in rate compare unfavorably with rate increases of only five per cent in each rate for industry as a whole.

Temporary disability injuries are about 95 per cent of all the injuries in the industry, on the basis of the 1934 reports. While substantial progress has been made in eliminating them, their severity, on the other hand, has increased seven per cent since 1929.

As in 1933, frequency rates were much lower in the largest plants and severity rates were about the same in plants in the other size group, during last year. Large plants averaged 8.67 in frequency rates, and 1.06 in severity. This marked a 23 per cent increase in the frequency rates and a 104 per cent gain in the severity rates. Small plants averaged 14.99 in their frequency rates, and .93 for severity. This represents an 18 per cent decrease in the frequency rates from 1933, and a 75 per cent increase in the severity rates.

Among the various types of plants, manufacturers of glass products have the highest 1934 injury rates, averaging 12.82 for frequency and 1.29 for severity. Manufacturers of flat drawn glass made the only improvement in frequency rate over 1933, namely 18 per cent. Manufacturers of incandescent lamps and radio tubes made the only reductions in severity, 45 per cent.

Companies making outstanding safety records last year are listed in the Council's Honor Roll for the industry. They are

Flat Drawn Glass: PITTSBURGH PLATE GLASS COMPANY. Works No. 4 of Ford City has the lowest 1934 frequency rate among large units, 3.55; also the lowest 1934 severity rate, 0.16. Works No. 6 of Ford City has the lowest 1934 frequency rate among small units, 1.73.

BINSWANGER AND COMPANY. Lowest 1934 severity rate among small units, 0.03.

Incandescent Lamps and Radio Tubes: RAYTHEON PRODUCTION COMPANY. Best 1934 record among large units; 1,686,000 man-hours without a disabling injury.

WESTINGHOUSE LAMP COMPANY. The Trenton, New Jersey, plant worked more hours without a disabling injury than any other small unit with a perfect 1934 record; 790,000.

Glass Products: OWENS-ILLINOIS GLASS COMPANY. The Gas City, Indiana, plant has the best 1934 record among large units, 1,639,000 man-hours without a disabling injury. The Columbus, Ohio, plant has made the largest reduction in frequency since 1932 among large units, 88 per cent; also, the largest reduction in severity, 92 per cent.

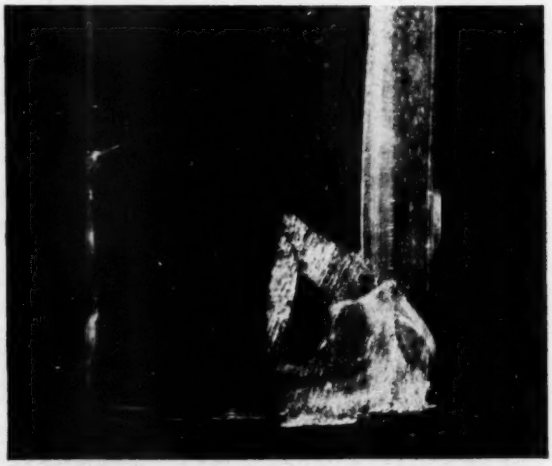
MARYLAND GLASS CORPORATION. Largest reduction in frequency since 1932 among small units, 71 per cent; also the largest reduction in severity, 78 per cent.

NEW USE DEPARTMENT

It is well known to all hunters, woodsmen, and campers that porcupines will eat almost anything, and seem to prefer materials as hard and as lacking in nourishment as possible. Everyone knows they like to eat aluminum kettles, outboard motors, the handles of oars, shoes, floorboards and other delectable items. It is perhaps less well known that they dine with glee upon deers' antlers (which may help explain why fallen antlers are rarely found in the woods); but it is apparently less well known that they will even chew up glass bottles.

The accompanying illustration shows a bottle, presumably originally containing catsup, on which a porcupine has exercised his teeth. He has ground a cavity or dish an inch or so across and a tenth of an inch deep in the glass. Possibly he had heard Morey say there was a ternary eutectic in it, and figured it ought to be good eating. Dr. Littleton supposes the animal took the glass for Pyrex, and was trying to get the pie, or possibly the eggs, out of it. He also suggests that maybe the creature had heard of Peate's grinding a concave mirror out of glass and was trying to emulate him, and succeeded fairly well.

Dr. Littleton and the writer are establishing a porcupine farm; it is our intention to use the animals to grind the concavity in the 200-inch mirror if Hostetter and Macaulay ever get it annealed.—F. W. P.



John Hopkins, Game Warden of Clarendon, Pa., presented this bottle and some others to Mr. Preston with the following comment: "I have found this chewing done on glass in several localities, so it is not just one porcupine that has been doing the chewing, but I believe all are in the habit of eating glass."

HEATING UP A GLASS TANK FURNACE

By Z. C. KLINE
General Electric Company

IT IS not the purpose of this paper* to offer a schedule of instructions for heating up a glass tank furnace. Rather it is the intent of the writer to bring out some of the factors which have to be considered in properly accomplishing the task. It is his hope that this may be done in such a manner that a non-technical person may readily understand. No original ideas, in particular, will be injected, although some of them may be new to many.

Every person remembers quite vividly certain outstanding events of his life. Most of us can recall lessons learned under unusual conditions—we were strongly impressed by them perhaps not because of their profundity, but rather because of their illuminating revelation of a truth. One such lesson came into my own experience as a student in a surveying class. The instructor in charge of our group was showing us how to set up a transit. In a quiet, conversational voice, he explained the various precautions to observe, and then he stopped, and in a rather apologetic manner told us that he always felt a bit reluctant to turn a sensitive, high-priced surveying instrument over to a bunch of new students. He said that so often young engineering students seemed to ignore their training and pay no heed to the fact that an adjusting screw on a surveyor's instrument was a very powerful engine. He said it really grieved him to witness men putting too much pressure on these screws springing the plate so much some times as to permanently damage the instrument. None of us had been guilty as yet of doing any harm, but it was doubtless because we had not had an opportunity. At any rate, we observed often after that how consistently respectful this man was toward his tools. He was a good teacher.

For nearly twenty-five years my work has been more or less closely associated with industrial furnaces. All this time they have seemed like individual personalities. Even when constructed alike they seemed to have peculiar differences in performance. In our industry the glass furnaces are the very heart of the process. When they are misbehaving the factory process is crippled, and because of this importance the glass furnaces have always appealed to me as individual, expensive implements. It has always hurt my sensibilities somewhat to see them abused or misused.

"No two furnaces will work alike, even though they are identical in structure," is almost a proverb in our industry. No doubt, this is true of furnaces in any other industry, as well. Every man who has struggled to get an unresponsive furnace to behave properly, exhausting all his bag of tricks, and still falling short of the goal, is willing to admit that furnaces are sometimes capricious, mysterious, and fickle. But let's be honest about it: we do know that there is always a cause for every effect, and reasons for results. With this in mind, we shall enumerate some of the factors that bear upon heating up a glass tank furnace.

Definitions. "Primarily, a furnace, considered as an elementary structure, is merely a hollow structure of refractory material, within which heat may be released." —A. D. Williams.

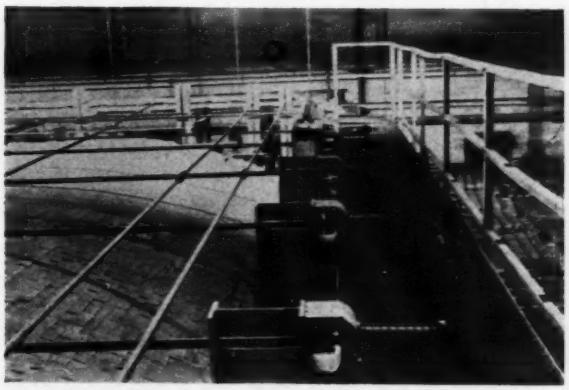
"Tank furnaces are those in which the lower walls of the combustion chamber actually serve to contain the molten glass without the intervention of a pot."

It might also be added that a tank furnace is one in which the open flame is above the hearth or bath; i. e., the combustion takes place in the furnace laboratory directly above the raw materials which compose the glass batch.

The Furnace Refractories Used. The refractories above the metal line are exposed to temperatures quite high, making it necessary to use a material that has a high softening point. Silica brick are generally used, although other high melting point refractories are sometimes employed.

The furnace walls in contact with the glass are usually made up of blocks of refractory material, which will withstand a relatively high temperature and still remain resistant to the attack of the glass and give no discoloration to it. Until recent years, it has been the general practice to use refractory blocks made of blended

* Read before the Conference on Glass Problems, Urbana, Illinois, May 31, 1935.



Safety walk mounted on the buckstays, method of tie-rod adjustment and bracings, described on page 212.

clays, much the same nature as that used for manufacture of glass melting pots. More recently other materials such as "Corhart," "B & W 80," and various other refractories have been used. These are denser and usually have better endurance in service. Being denser makes them generally better conductors of heat than "pot-clay" or "flux" blocks.

In view of the foregoing statements we shall consider for this discussion, that the glass tank furnace is constructed of silica brick in the super structure, and of clay blocks in the hearth. Our main consideration shall be the heating of the furnace proper; however, we do have to keep in mind those parts of the furnace unit which are necessary for its functioning, such as the regenerators, flues, valves, and the stack.

Table I. Physical and Chemical Properties of Some Refractories Used in the Tank Furnace Superstructure

	Composition	Fusion Pt.	Softening Pt. Under Load
1. Silica Brick	95% SiO_2	1720°-1750°C	1620°-1650°C
2. Clay Brick	45% Al_2O_3 / 50% SiO_2	1650°-1720°C	1250°-1350°C
3. Sillimanite Brick	$Al_2O_3SiO_2$	1816°C	1700°C

	Sp. Gr.	% of Vol. Porosity Coef.	9/Gal./Cen./°C. Conductivity
			.0026 (200°)
			.00426 (1000°)
1. Silica Brick	2.29-2.45	17-25	.0050 (1370°)
2. Clay Brick	2.62-2.72	20-25	.0042 (1000°)
3. Sillimanite	3.2	15	.0044 (900°)

Table II. Physical and Chemical Properties of Some Refractories Used in the Tank Furnace Superstructure

	Sp. Heat	Linear Coef. of Expansion	Heat Shock Factor Magnesite Brick = 100
1. Silica Brick (95% SiO_2)	.227 (25°-600°C)	1.21 x 10^{-5}	
	.295 (25°-1400°C)	(14°-1260°C)	75
2. Clay Brick 45% Al_2O_3 50% SiO_2	.297 (14°-1400°C)	.59 x 10^{-5}	3-30
3. Sillimanite	.168	.48 x 10^{-5}	good

There are two parts, chiefly to our present problem: 1. Bringing the furnace unit from room temperature

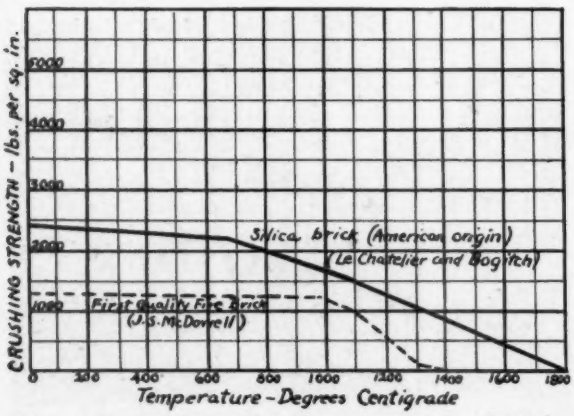


Fig. 1. Comparison of crushing strength of refractories.

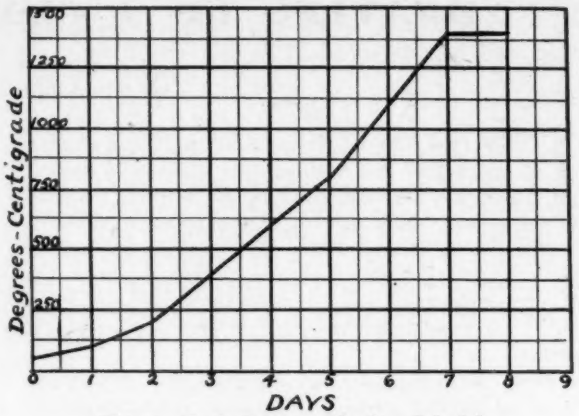


Fig. 2. Tank Furnace Heating Schedule.

up to its operating temperature. 2. Accomplishing the result efficiently, and without damage to any of its parts.

Damour, in speaking of industrial furnaces states that there are many variables to be taken into consideration. He mentions five in particular: high temperature, economy, various combustibles, fixed dimensions of the furnace or its heating chamber, and a certain industrial operation.

Even in heating an empty furnace there are several variables to think of. Tentatively, we have assumed certain refractories for our case. We need to select a source, or sources, of heat energy. Such matters as availability, cost, ease of control and previous experience with particular fuels have to be considered in making the choice. Wood, coke, coal briquets, artificial gas, fuel oil, producer gas, and natural gas have all been used in the writer's experience. All of these, fundamentally, of course, mean that the fuel is burned as a gas in the furnace heating chamber.

Heating Schedule. A few of the variables affecting the rate of heating up a furnace are: 1. The endurance of the refractories to thermal shock. 2. The rapidity with which they conduct heat. 3. Their initial condition as to dryness. 4. The skill of the furnacemen in keeping the temperatures uniform throughout the furnace. 5. The need of the furnace in production.

Those who have had experience heating up green glass melting pots appreciate that it is absolutely necessary to effect this operation without cracking the pot. To do this, it is essential that the temperature of the whole pot arch chamber be brought up gradually and uniformly so that the pot, in its every section, be warmed equally to avoid dangerous stress in any part. The green pot clay demands unusual care in heating through the "water smoking" period—up to 150° C. This is the stage when the uncombined water is driven off. The tank blocks fortunately have been thoroughly burned before they leave the block factory, so we do not have to be concerned about the critical water smoking period.

It is, however, a difficult matter to heat the blocks in position in the furnace. This arises from the fact that the outside surface of the blocks is exposed to room temperature while at the same time the inside surface of the blocks is exposed to the hot gases inside the furnace. This makes a temperature differential between the two sides of the block, setting up a stress which sometimes causes the block to crack. The blocks

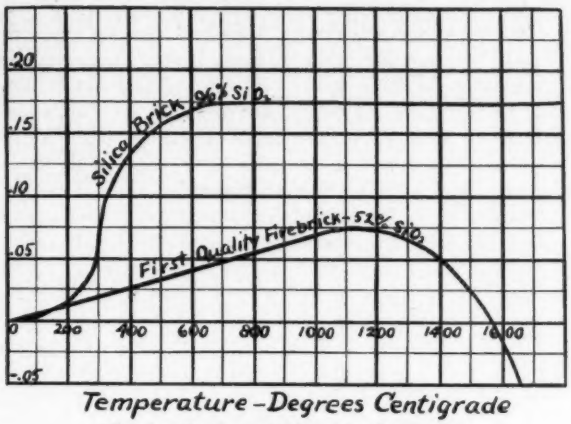


Fig. 3. Heat expansion of refractories.

which are the best conductors of heat are spared the greatest strain since there is a smaller differential in temperature between the two surfaces. However, there is another variable—some materials will stand more stress than others before they break.

Brownlee and Gorton gave the following schedule as suitable for heating a green clay glass melting pot in a pot arch:

Table III. Pot Heating Schedule

Brownlee and Gorton suggest, without reference to size, the following as a useful guide in raising the temperature of a pot:

Internal Temperature (in degrees Cent.)	Time Needed (Hours)	Rate of Heating (degrees per hour)
27- 200	40	8
200- 480	41	12
480- 815	60	10
815-1200	35	20
	Total 176 (7 days-8 hrs.)	

We have used an almost identical schedule successfully in pot-arch practice for a number of years, the only difference being that we took forty-eight hours to come up to 150° C.

A twelve-inch clay block is thicker in section than a pot; but on the other hand it has a much more rugged shape, being of plain rectangular form, and has been carefully burned before being shipped from the block factory. These two characteristics ought to make it possible to safely use at least as rapid a heating schedule as is used in heating green clay pots.

In the U. S. Bureau of Standards, Technical Paper No. 7, it is shown that the load test on silica brick is conducted in the usual form of load test furnace. The load is twenty-five pounds per square inch. The heating schedule would require a little over *six hours.*

In making load tests on silica brick it was found that if heated to 700° C at the same rate as clay brick (270° C in 20 minutes, 520° C in 40 minutes, and 670° C in 60 minutes), the specimens invariably spalled; and that spalling apparently ceased when the rate of heating below 500° C was decreased to 50° C in 15 minutes. Measurements of the linear expansion of bricks during the load test indicate that the spalling is practically all due to the alpha-beta cristobalite inversion, which takes place at 220°-275° C.

From the foregoing, we may conclude that it is safe to the structure of a silica brick to heat it quite rapidly provided the temperature is brought up uniformly. Relatively, it would appear that the time for safely heating silica brick might be shorter than that required for heating the heavy clay blocks of a glass tank furnace. Therefore, we may conclude that the limiting time factor for safely heating up a glass tank furnace is the length of the time required for heating the clay blocks of the bottom and the side walls.

In our tank furnace practice, we have for a number of years used the following heating schedule for heating up a tank furnace. When there is green masonry work of any amount, we take a day or two longer so as to carefully dry out the green refractories and mortar.

Furnace Design—Expansion Slots. It is not the purpose of this paper to discuss furnace design. We shall assume that proper provision has been made in the furnace structure to permit expansion of the refractories, provided the temperature is raised properly and the supporting steel work is correctly adjusted. The refractories may be damaged by mistreatment from improper heating, or by neglect to provide properly for their expansion as the temperature rises.

Since expansion of silica bricks is bound to occur on heating, and contraction on cooling, constant attention to furnace tie rods is necessary to prevent serious damage. Tension on these must be relieved during heating, and increased during cooling. The volume changes indicated are accompanied by changes in specific gravity. These changes are slow. Silica brick stand up better under load than fire clay brick. Silica bricks expand approximately 10 per cent in volume and about one-tenth to three-sixteenths of an inch to the lineal foot.

"The stresses in the furnace are almost wholly compression in the refractories, while the tension component is taken care of by the binding of the furnace, that is, the steel work such as buck stays, tie rods, etc."

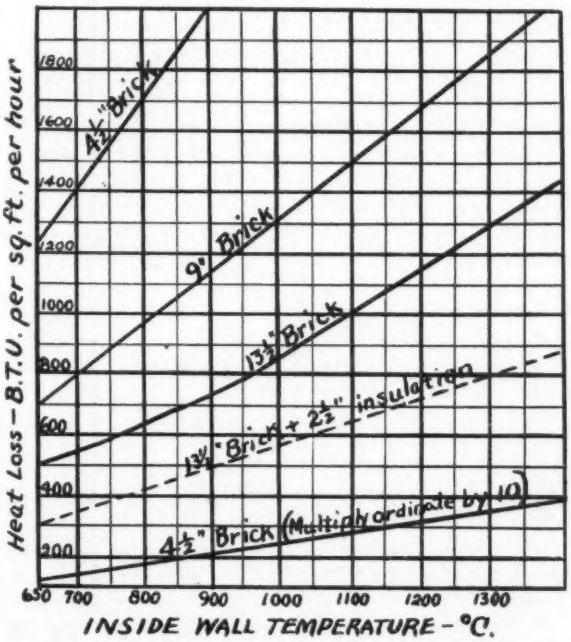


Fig. 4. Heat loss through furnace walls (for atmospheric pressure in furnace).

Adjustment of Tie Rods. The adjustment of tension on the tie rods of the furnace is a very inaccurate procedure if the furnacemen have to guess at the proper tension by tapping the tie rods, or stepping on them to estimate how tight they are. To take the guesswork out of this job, we decided to try mounting heavy coiled springs on one end of the tie rods, throwing the tie rod tension on these springs when heating a furnace, and when cooling it. When the temperature is up to its operating level, the inside nut is tightened against the buckstay and the nut compressing the spring is set free, releasing the tension on the spring.

IT MAY be of interest to learn that this principle was patented about 80 years ago and was used to some extent on steel furnaces. By compressing the spring more or less the tension may be changed. Once the tension is set the length of the compressed spring is marked on the buckstay and the furnaceman draws up or lets out the nut holding the spring just enough to keep the spring the proper length. This is done every hour or two while the silica is changing volume rapidly.

The safety walk shown mounted on the buckstays is a great convenience to the furnacemen. It is much appreciated by them.

Bracing on Bottom Blocks. The bracing against bottom blocks is kept merely snug to permit them to creep out as they expand. When the furnace bottom blocks are laid new, it is our custom to have expansion slots left to take care of most of the block bottom expansion. This allows the bottom blocks under the side blocks to remain in their original location and prevents tipping the sidewall blocks.

It was the writer's experience once to observe a tank accidentally drained by the slipping of a bottom block sidewise. The bottom blocks in the tank had not been braced and one block drifted sidewise three quarters of an inch leaving a long narrow slot through which the hot glass quickly drained into the furnace pit.

Cullet in the Cold Furnace. It has been the custom in some glass plants to put cullet in the tank before heating it. It is obvious that this material will act as an insulator of the blocks covered by it, keeping the heat away from the blocks until the cullet is melted. At that time, the molten cullet, will quite readily transmit radiant heat to the protected blocks which will be thereby subjected to quite a sudden change in temperature. Perhaps such a practice is safe if the heating schedule for the furnace is not rapid.

Method of Applying the Heat. The operation of warming up a furnace ought to be touched on briefly. If the masonry work is new, the mortar green, it would seem best to put slow drying fires in the flues under the regenerators allowing the warm gases to ascend through the necks into the furnace and escape through cracks, expansion slots, etc. However, if the regenerators, flues, necks and the like are dry, it is easier and quicker to place several gas pipes in the furnace, in the melting chamber, and also in the refining chamber, bending the burner end downward so that the lower part of the lighted flame is about eighteen inches above the bottom blocks. Be careful that no flame impinges on any refractory until the refractories are fairly hot.

The objective is to heat all parts of the furnace—walls, crown, and bottom—as uniformly as possible. It is helpful to use a luminous flame and thus get as much benefit as possible from radiant heat. Heat can be transmitted in three ways: By conduction, convection, and by radiation. If the furnace gases are non-luminous, radiation is very much reduced, although not wholly absent, and convection becomes very important. It is known from experience that transmission of heat by radiation is, at least at high temperatures, much more energetic than transmission by convection. Furnace operators know that with a luminous flame, a given furnace has a much greater capacity than it would have if the combustion gases were clear and transparent.

"It may be remarked in passing, that luminosity of furnace flames is caused principally by glowing carbon particles floating in the gas stream, and is always a sign of incomplete combustion at the place where it occurs."

Furnace "Setting" When Lighted. Before lighting the fire, we close the furnace chamber openings fairly tight, covering expansion slots in the crown by laying bricks over them and luting them shut with sand-lime mixture. Of course there are quite a large number of small openings between blocks, and in the sidewall expansion slots, etc., which allow fresh air to enter the furnace chamber to support combustion. The stack damper, intermediate damper, air valves and reversing gas valve on flues are all closed for the first two days. If the regenerators and flues have no green masonry, we do not put drying out fires in the flues, but depend on drawing warm gases down from the furnace chamber after the second day.

THE gas for the first day or two obtains sufficient air for its combustion from the air passing into the furnace through cracks and miscellaneous holes. As the amount of gas is increased, there is a haziness in the furnace due to insufficient air to burn the gas. At this time, a fire is lighted at the base of the furnace stack and we open the stack damper slightly, and begin reversing the furnace valves about once an hour. (This practice is for a regenerative furnace). This procedure draws the combustion gases down through the regenerators and these begin to warm up. From this time on, the amount of fuel is increased gradually as required, and we attempt to keep the flame luminous and the exit gases nearly neutral as for oxygen.

Pyrometer elements are placed in the furnace chambers, usually one in the melting end, and one in the refining end. These indicate the temperature at two points only, but at the lower temperatures the furnacemen supplement these by using their hands on the outside surface of the refractories. The sense of touch is quite dependable at low temperatures and by going around the furnace feeling the blocks and walls at various elevations, the furnaceman gets correct information. He actually feels his furnace coming into life. Psychologically, we believe this is beneficial. The furnaceman quickly diagnoses faulty heating if it is occurring at any part of the furnace. Suppose the silica walls above the metal line are getting quite warm to the touch, but the side wall blocks are barely showing any warmth, and the bottom blocks are still damp and cold to the touch. The pyrometer doesn't tell that story, but the furnaceman is immediately aware that he must make

adjustments to get the hot gases better distributed in the furnace chamber, or perhaps obtain a more luminous flame to get more help from radiant heat in the lower part of the furnace chamber. Perhaps there are too many openings in the superstructure allowing the lighter, hot gases to escape at the top. We will touch on this matter further on.

A VERY important factor to be considered is the attitude of the furnacemen. No doubt in every glass plant, the furnacemen are looked on by all employees as men who "count" or "rate." We have always encouraged this, emphasizing the fact that furnacemen carry a lot of responsibility. We try to develop recognition of the dignity of their particular jobs. Surely these men occupy key positions in the factory, and we think it well worth while to take pains to inform them in as practical a manner as possible why we observe certain precautions in heating up a furnace. When men have a strong desire for anything, they are ever on the alert to find ways and means of satisfying that desire. Thus, if we have well informed furnacemen—men of the right sort—they are always endeavoring to do their work correctly, and they become more resourceful. And what a boon that is to the factory management!

Flow of Gases in Furnaces. Earlier in this paper we remarked that the fuels considered for heating up the tank furnace were all burned in the furnace combustion chamber as gases. Commonly we do not think of there being much difference in the physical properties of the same gas at different temperatures. We have learned that gases diffuse readily. That is, for instance, two gases of widely different molecular weight, such as hydrogen and oxygen will diffuse (mix) thoroughly, they will not stratify in a vessel. The hydrogen, being lighter does not separate from the oxygen and rise to the top of a closed vessel leaving the heavier oxygen at the bottom of the vessel.

We normally do not think of the air in which we move as having weight although we realize that we do not go about in a vacuum. We seem to ignore it even in our furnace practice. Oh, we all know that we need air to burn the gases in the furnace, but we usually fail to comprehend the remarkable changes that take place when the temperature of a gas is raised. A cubic foot of gas at room temperature weighs approximately seven times as much as a cubic foot of the same gas at 1600°C (Temperature of an open hearth furnace in operation).

Table IV. Expansion of Gases

It is known that the coefficient of expansion of gases is 1/273; if, therefore, the specific weight of air at 0° is considered unity:

at	273°	its	specific	weight	will	be 1/2
at	546°	"	"	"	"	" 1/3
at	819°	"	"	"	"	" 1/4
at	1092°	"	"	"	"	" 1/5
at	1365°	"	"	"	"	" 1/6

This means that one cu. ft. of free air of room temperature will expand to over six cu. ft. at the temperature of the melting chamber of a glass tank furnace.

In the preface to the French edition of Prof. Groume-Grjimailo's "Flow of Gases in Furnaces," LeChatelier says: "The researches of Professor Groume-Grjimailo bring us to a new idea. He has set forth a principle in regard to the circulation of the hot gases within furnaces: a very simple principle, but one that has not heretofore been recognized. We have always considered that gases, by reason of their absolute elasticity, completely fill the chamber in which they are enclosed. Then, by a process of unconscious deduction, without any sound basis, we conclude that in circulating through a series of successive chambers or flues, they fill equally the entire cross-section of those chambers through which they pass and that their current sweeps uniformly through all the passages or flues which are open to them in proportion to the area of these passages. Perhaps we should not formulate this erroneous principle in such exact terms; nevertheless, we proceed as though we firmly believed that it was correct, and it certainly follows, notably in the construction of furnaces, that very serious errors are made.

"A phenomenon is more readily understood when it is compared with something that we have always before us. We see a stream of water flowing in its bed, resting upon the soil and bounded upon three sides by the surface of the ground. Its upper surface is separated from the atmospheric air above, by a horizontal plane, the position of which is not fixed and which varies in accordance with the volume of water flowing. The hot gases in a furnace tend to circulate in exactly the same manner, with this single difference, that the plane of separation is below, and the profile of the bed of the stream is formed by the roof and walls of the furnace. As this comparison shows, we have heretofore erroneously considered that the flame filled the entire furnace and heated it uniformly, when in reality the hot gases may circulate only in the upper portion of the heating chamber, without coming into any contact with the material which has been placed upon the hearth. The utilization of the heat in this case will be very inefficient. The stream of fire which flows against the roof will carry all its heat to the chimney.

"THE reason for this lies in the high coefficient of expansion of gases; that is in the fact that their density diminishes very rapidly as their temperature increases. Therefore, the hydrostatic equilibrium of the different layers of gases, which are at different temperatures, is accomplished with great rapidity, and the hottest gases tend to accumulate at the highest point in the furnace. If the opening for the escape of the waste gases is located at the highest point of the roof of the furnace, the greatest portion of the heat will be lost. It is necessary, in order to avoid such heat loss, to employ the down draft principle of heating."

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DISCUSSION FOLLOWING MR. KLINE'S PAPER

The discussion following Mr. Kline's paper was led by J. W. Wright, Owens-Illinois Glass Company, who pointed out that furnaces constructed from the same drawings do not act alike but comparable results are expected. Many times the persons having to heat up and operate a glass tank make certain useful observations on behavior but these are usually discounted because the analysis as to cause is faulty. These observations should be heeded and some competent person should cooperate in helping with the interpretation. In one installation, for instance, difficulties encountered in a factory every morning were

(*Continued on page* 224)

INSULATION OF GLASS FURNACE REGENERATORS*

J. E. McBURNEY
Owens-Illinois Glass Company

ALTHOUGH there has been much talk about insulating glass furnaces, and it has been done in a few instances, it is not a general practice. All of the latest open hearth furnaces as well as most of the older ones, are completely insulated, including the roof, ports, slag pockets, and regenerators.

The glass industry is a little backward about insulating its tanks, due mainly to adverse results obtained some time ago when various attempts were made to insulate the furnace cap. With all due respect to those who made these early installations, the apparent reason for failure was the method of insulation and furnace operation.

Since these early attempts, glass men have proceeded very cautiously along the line of insulation. But there is no reason to believe that it is not as practical and plausible to completely insulate glass tanks as it is to insulate open hearths. In the latter, hearth temperatures higher by several hundred degrees are maintained and, on account of the operating cycles, the roof and other parts of the furnace system are subjected to much greater temperature changes. Glass furnaces operate at a practically constant hearth temperature, with the result that minimum variations are obtained in the balance of the system.

Most of the insulation applied to the larger glass furnaces during the past few years has been confined to the regenerators, although it is understood that several furnace caps have been insulated recently. The results of these installations are not known although, if conditions are "right," there is no reason why they will not be favorable.

The effect of insulation should show up in fuel consumption. In final analysis, the fuel requirement tells the story. However, from an analytical standpoint, the changes in temperatures in the brickwork and throughout the furnace system as well as in waste gas analyses, are also important; inasmuch as it is by the use of these data that predictions can be made of the results anticipated on future installations.

Based on hot plate tests, which is the accepted standard method, the conductivity of the insulating materials can be readily calculated. The heat loss and surface temperatures of various combinations of installation and brickwork can then be figured for use in determining the extent of insulating from the economical viewpoint. After the insulation is made, to determine the existing temperatures presents a rather difficult problem.

When measuring surface temperatures, it is desirable to employ a method which is relatively fast and quite accurate. One of the simplest means that can be used is a bare thermocouple held against the surface by an asbestos pad. This gives considerable inaccuracy and it is usually impossible to check previous readings. Variations of 15 to 50 degrees are normally obtained due to the insulating effect of the asbestos pad.

A better method, and one which is satisfactory for field work, is to use a contact thermocouple. The couple is so made that the wires forming it are coiled, giving a spring effect, which assures a constant pressure at all times on the surface to be measured. The couple is enclosed by a small slotted protection tube which eliminates insulation of the bead.

It is necessary to apply a correction factor to the contact couple readings to obtain accurate indications. For measuring metal surface temperatures, the correction factor may be determined by checking against a couple which has its junction or wires peened into the metal. The correction, in this case, is usually relatively small, due to the high heat conductivity of the metal.

For measuring surface temperatures of low conductivity materials; such as insulation, firebrick and refractories, the contact pyrometer should be checked against a thermocouple cemented to the surface, the couple wires running along the surface for several inches to prevent heat flow from the junction to the cooler wires. The temperature between the brickwork and insulation can be accurately measured by a thermocouple cemented to the wall, after which the insulation is put in place. While the methods mentioned above may not give absolutely accurate temperature indications such as could be obtained in a laboratory, it is believed they are sufficiently accurate for field work.

It is also important to make temperature measurements of air and waste gases when attempting to determine the effect of insulation on regenerators. This can be most accurately accomplished by employing an inspirating thermocouple, wherein the gases (or air) are inspirated around the junction, which is protected from radiation of surrounding surfaces by an alloy tube. Ordinary bare thermocouples are not recommended for this purpose, as erroneous readings will be obtained. Too high an indication will be given when the air is being heated, whereas low temperatures will be obtained where the gases are giving up heat to the surrounding brickwork.

The following data were obtained from a glass tank where the sides and cap of the regenerators as well as the port necks were insulated. The furnace was producing 106 tons of milk bottle glass per day. It had six ports on each side and the checker height in the regenerators was 11 feet six inches.

The installation consisted of a 4 in. thickness of glass wool, held in place by sheet iron castings, on the sides and ends of the regenerator. The regenerator caps and port necks were covered with 2½ inches of glass wool cement.

The job was performed in three steps: First, the port necks and regenerator arches were sealed and then insulated with glass wool cement. Second, the regenerator walls were sealed. Third, the regenerator walls were insulated with 4 inches of glass wool.

By proceeding in this manner it was possible to determine the effect of each step.

Before starting to insulate, various data were collected with which comparisons could be made of similar data obtained at the different stages as mentioned above. They are as follows:

Fuel consumption: 762,000 cu. ft. of natural gas per 24 hours.

Preheat of air at back of ports (before reversal): 1914° F.

Waste gas temperatures in regenerator canal (before reversal): 1210° F.

Increase in O_2 content of waste gases between back of ports and regenerator canal: 2.74 per cent.

The port necks and regenerator caps were then sealed with a mixture of silicate of soda, finely ground fire clay and water. Two and one-half inches of glass wool cement were then put on. This cement consisted of nodulated glass wool to which a small amount of clay was added as a binder. It was applied in manner similar to that recommended for the numerous insulating cements now on the market.

Twenty-four hours after this portion of the job was completed, another set of data was collected, indicating:

Fuel consumption: 756,000 cu. ft. per day.

Preheat of air at back of ports (before reversal): 1922° F.

Waste gas temperature in regenerator canal (before reversal): 1250° F.

Increase in O_2 content of waste gases between back of ports and regenerator canal: 2.00 per cent.

Compared to the first set of figures, it is seen that the fuel consumption was reduced 6,000 cu. ft., or less than 1 per cent, by insulating the regenerator arches and port necks. An increase in air preheat and waste gas temperatures was obtained. A noticeable reduction in air infiltration was brought about, the increase being reduced by .74 per cent.

The regenerator side walls were next sealed with a silicate of soda, fire clay, and water mixture. When the furnace conditions settled, after completing the sealing, a third set of data was taken, showing:

Fuel consumption: 737,000 cu. ft. per day.

Preheat of air at back of ports (before reversal): 1931° F.

Waste gas temperature in regenerator canal (before reversal): 1280° F.

Increase in O_2 content of waste gases between back of ports and regenerator canal: .72 per cent.

The most outstanding difference between the second and third sets of data is the decrease in the amount of air infiltration. Whereas before sealing, the oxygen increased 2.00 per cent from port to regenerator canal, after sealing, it was only .72 per cent. The effect of this is reflected in the other figures, showing an increase in waste gas temperature, a slight increase in air preheat and an appreciable reduction in fuel consumption. 19,000 cubic feet of gas were saved, or about 2.5 per cent.

From all outward appearances, the regenerators were originally "tight," no cracks showing up around any of the bricks. Although the walls were not new, they were in good condition. Still, the infiltration of air amounted to 35,000 cu. ft. per hour. The sealing reduced this to 6,400 cu. ft. per hour.

The glass wool was then placed on the regenerator walls. Several days after the completion of this last step, a fourth set of data was collected.

Fuel consumption: 701,000 cu. ft. per day.

Preheat of air at back of ports (before reversal): 1935° F.

Waste gas temperature in regenerator canal (before reversal): 1235° F.

Increase in O_2 content of waste gases between back of ports and regenerator canal: .25 per cent.

It is seen that a 36,000 cu. ft. reduction was brought about by the insulation of the regenerators. A very slight increase in preheat was obtained, although the waste gas temperature in the regenerator canal decreased.

Due to a more efficient reclamation of heat in the regenerators, the temperature of the air remained about the same in spite of the fact that the volume of waste gases was decreased appreciably. Had the smaller amount of gas been burned before the regenerators were insulated, the waste gas temperature would probably have been almost a hundred degrees lower and the air preheat been in the neighborhood of 1850°.

Reviewing the daily fuel savings obtained as the work progressed, it is found that a 6,000 cu. ft. reduction was made by sealing and insulating the port necks and regenerator caps; 19,000 cu. ft. were saved by sealing the regenerator walls, and 36,000 cu. ft. were saved by insulating the regenerator walls. Total savings: 61,000 cu. ft. or 8 per cent of the original consumption.

It will be noted that about 90 per cent of the fuel reduction resulted from the sealing and insulating of the regenerator walls. The sealing, which eliminated practically all of the infiltration, saved 19,000 cu. ft., or approximately 2.4 per cent of the total; whereas the insulation, which reduced the heat losses through the walls and further reduced the infiltration slightly, saved 36,000 cu. ft., or about 4.7 per cent of the total.

If the walls had not been sealed prior to placing the insulation, the effect of the insulation would probably have been a reduction of 55,000 cu. ft., or slightly less. However, only 66 per cent of this reduction would have been due to the decrease in heat losses; the other 34 per cent being due to the elimination of air infiltration. The importance of sealed walls is thus quite evident.

Numerous temperature measurements were taken at various locations of the surface of metal casing and the glass wool cement as well as of the brick under the insulation. Due to differences in the amount of air circulating around these surfaces, the readings were not consistent. In between ports, for example, the temperatures averaged 1012° and 256° at the brick and insulation joint, and the insulation surface, respectively. At the end of the ports, these temperatures averaged 892° and 205° respectively. The brick thickness was 9 inches, and the insulation 2½ inches.

Similar inconsistencies existed on the regenerator walls. However, the average temperature of the brickwork was 910° at the top of the checkers, with 215° for the metal casing which held the insulation. Two feet up from the bottom of the checkers, the brick surface indicated 500° and the casing 140°. The regenerator walls were 13½ inches thick, insulated with 4 inches of glass wool.

When considering the insulation of regenerators, sight should not be lost of the effect of tightly sealing the walls. The cost of sealing is relatively small compared to the cost of insulating; but the returns, due to the reduction of infiltration, are much greater in proportion to the original cost.

It should be remembered that the data presented deals with only one furnace and hence the results obtained on other similar installations may or may not be the same.

* Read before the Conference on Glass Problems, University of Illinois, Department of Ceramics, June, 1935.

A NEW BORAX PRODUCT

By W. RONALD LESTER
Maryland Glass Corporation

DURING the past five years, the use of ordinary borax ($Na_2B_4O_7.10H_2O$) in the production of commercial soda-lime-silica glasses has become quite common practice. The advantages of this powerful flux and durability agent in improving the properties of these glasses have been well recognized. A large number of domestic and Canadian glass plants have come to regard it as an essential raw material, generally employing it in quantities varying from 60 to 120 pounds per ton of sand.

After several years of research and experimentation, one of the largest producers of borax in the world has succeeded in developing a new and improved form of borax for use in the glass and ceramic industries. The new product is a dehydrated borax known as Pyrobor[1], and possesses several distinct advantages.

Borax in hydrated form ordinarily contains about 47 per cent by weight of "water of crystallization," which must be driven off during the melting process. Unlike borax "glass," which is an amorphous and not completely dehydrated form of borax, Pyrobor is crystalline in nature, and by virtue of the process employed in its production, it is practically free from water, containing less than 0.5 per cent by weight. Although ordinary borax has proved to be of definite value to the glass industry and its use has become general, tests have indicated that this batch material in anhydrous form would constitute a further important improvement.

The history of the development of this product as related by the manufacturer is exceptionally interesting. The company states: "Ways and means of producing such a product in suitable form for use in the glass batch were carefully investigated, the essential aim being to develop an economical process that would permit its delivery to the consumer without any increase in cost per unit of B_2O_3 or $Na_2B_4O_7$. In other words, the dehydrated material had to be produced at a cost which was approximately equivalent to the freight saving involved. As the existing methods for converting borax into anhydrous form were not suitable, either from a standpoint of cost or of characteristics of the finished product, it was necessary to develop an entirely new dehydration process.

"The equipment and process employed in the production of Pyrobor are described in U. S. Patent No. 1,964,-902. Briefly, the process, a continuous one, involves (1) the partial dehydration of borax at relatively low temperatures; (2) fusion, during which the greater part of the remaining 'water of crystallization' is removed; and (3) cooling in molds under proper conditions to effect crystallization and, at the same time, the removal of the last traces of water. The final product is exceedingly friable and easily reduced to suitable grain sizes. The comparative properties of ordinary borax and dehydrated borax, are shown in Table I:

Table I.

	Borax	Pyrobor
Formula	$Na_2B_4O_7.10H_2O$	$Na_2B_4O_7$
Melting Point	*	1330-1335°F
Specific Gravity	1.69	2.36
Bulk Density	63 lbs./cu. ft.	82 lbs./cu. ft.
Composition (approximate)	Per cent	Per cent
$Na_2B_4O_7$	53.0±	99 +
B_2O_3	36.6	68.5+
Na_2O	16.4	30.4
H_2O	47.4	less than 0.5

"About two years ago, a small pilot plant using this process was placed into operation. The production of this one unit was, of course, not large enough to supply the entire requirements of the glass and ceramic industries. However, before building additional units it was thought advisable definitely to ascertain the conversion costs of borax to dehydrated borax, and further to confirm the apparent advantages of the latter product. Sales were, therefore, restricted to several large, well known glass plants which had been using ordinary borax for a considerable period and thus were able to judge the merits of the new product. Reports from these plants are particularly favorable to the new dehydrated borax and in each instance it has been adopted as a regular constituent of the glass batch. This has encouraged us to enlarge production facilities to a point where dehydrated borax is now on a tonnage basis."

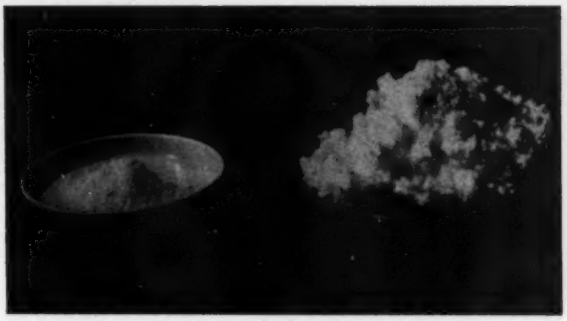
The following are the results of comparative tests,

[1] Registered, U. S. Pat. Off., American Potash & Chemical Corporation.

* Melts in its own water of crystallization or intumesces, depending upon conditions.

Fig. 1. Original materials, before heating, with Pyrobor on the left.

Fig. 2 (right) The same after 1.5 min. at 1022°F.



(left) Fig. 3. After an additional 4.5 min. at 752-842°F. (right) Fig. 4. Later, after an additional 1.5 min. at 1472°F.

made under laboratory conditions, on the behavior of Pyrobor and borax on heating:

Figures 1 to 5 show the relative melting behavior of Pyrobor and ordinary borax. 1.06 grams of Pyrobor and the equivalent quantity of borax (2.0 grams) were melted in a furnace at the same time. The specimens were then removed at arbitrary intervals to show the various stages of fusion. As will be noted, the Pyrobor remained unchanged until the fusion temperature was reached and then melted sharply. The borax started to intumesce at a low temperature, continued to puff up to a maximum (Fig. 3), shrank (Fig. 4), and, finally, fused (Fig. 5). The final heating of both samples was continued for 2.5 minutes. At the end of this period both samples were completely fused but the borax sample was not entirely "seed free."

From the results of our laboratory tests such as described above, and from our actual plant experiences, we have found that Pyrobor has the following advantages over ordinary borax:

1. Puffing is eliminated, consequently there are no light particles to be blown about by furnace drafts, which often cause some mechanical loss of material. This puffing defect is very noticeable in furnaces operating under high positive pressures and where the doghouse sting-out passes over the incoming batch. Under these conditions the borax on the surface of the batch puffs quickly and the resulting "popcorn" is blown out of the doghouse settling around the factory and causing an unsightly appearance.

2. "Fluxing action" is much quicker, since no time lag is involved in carrying Pyrobor through the various stages to complete fusion. Pyrobor melts quickly, glazes the surface of the batch and begins its attack upon the other batch materials almost immediately.

3. The strong and early fluxing action of Pyrobor also decreases the tendency to scum formation.

4. Less heat is required to melt Pyrobor, the water of crystallization having been removed.

5. In actual practice, when Pyrobor has been employed it has been noticed that the glass "fines" still more rapidly. This increased "fining" action may be due to the fact that, since there is less mechanical loss of $Na_2B_4O_7$ the full value of borax in decreasing the surface tension of the glass and thereby increasing the ease of gas evolution is realized.

6. Due to the higher bulk density of Pyrobor (82 lbs./cu. ft. as against 63 lbs./cu. ft. for ordinary borax) less space is required for storage. This is also an advantage in cases where the coloring materials, arsenic, nitre, etc., are mixed in small mixing machines along with the borax material prior to their introduction into the large batch.

STANDARDS FOR GRINDING WHEELS

The National Bureau of Standards has announced that Simplified Practice Recommendation R45-32, Grinding Wheels, has been reaffirmed, without change, by the Standing Committee of the industry. This simplification program lists standard wheels of various types of artificial abrasive grinding wheels, and the data is so arranged as to make convenient the locating of particular wheels designed for specific purposes.

Fig. 5. Both samples after receiving an additional 4 min. at 1616°F.

The production of Polished Plate Glass for the month of May, 1935, was 14,581,557 sq. ft., as compared to 16,998,914 sq. ft. produced in the month of April.

FILMS GIVE MOMENTUM TO MODERNIZATION DRIVE

The Federal Housing Administration has raised the borrowing limits from $2,000 to $50,000 in order to make it possible for owners of large buildings to modernize. This announcement has been capitalized by Pittsburgh Plate Glass Co. and Westinghouse, who have jointly sponsored a series of sound features dealing with store fronts and lighting.

Each film is a complete story in itself and lasts ten minutes. This permits showings of ten, twenty, thirty or forty minutes. The first film, "The Eyes Have It," graphically portrays striking examples of the best type front for various businesses and the importance of individualized exteriors. "Here's How," the second film, presents actual case histories of dingy stores amazingly transformed into business-getting establishments. Statements of owners showing actual sale and profit increases amply prove the value of such modernization. Next comes "Dollars on Parade" which deals with the important but frequently neglected subject of proper show window illumination. Information compiled by lighting experts is dramatically presented and specific lighting recommendations are made for various types of display windows. To complete this interesting story on the value of modernization, the final film, "Selling with Light" shows examples of dreary interiors and inefficient show cases. Their increased power of attraction, after the suggestions of illuminating engineers have been followed, are fully shown and the reasons for this great improvement are interestingly demonstrated.

A CORRECTION

A misstatement appeared in last month's GLASS INDUSTRY which we are most anxious to correct. It stated in effect that by vote of the Board of Trustees of Alfred University, engineering students of the Ceramic College must join the A.C.S. Membership dues $5.00. Number of students 204. Total, over $1,000 in dues for the A.C.S. This report was erroneous, and no such action was taken by the Board.

INCO DEVELOPS NEW METAL

A special nickel cast iron so hard that it will scratch glass is described in a patent recently issued to research engineers of the International Nickel Company. The main applications for this iron, which is five times as hard as ordinary iron, are for machinery parts which are exposed to severe wear and abrasion.

Employees of the Pittsburgh Plate Glass Company gave a spring dance and card party at the Hotel Schenley, Pittsburgh on June 7. Danny Nirella and his orchestra provided the dance music. Entertainment features were sprinkled lavishly through the evening and the affair was a pronounced success.

LIBBEY-OWENS-FORD EXPANDS OTTAWA PLANT

The Libbey-Owens-Ford Glass Company, Toledo, will spend $1,000,000 in expanding the Ottawa, Ill., factory which it purchased from General Motors a few years ago. Grinding and polishing lines will be re-equipped and modernized. Storage facilities for plate glass will be added, and complete equipment installed for the production of laminated safety glass. No new buildings will be erected. These betterments will make the Ottawa plant a complete, self contained unit, in which every step from the manufacture of the glass through to the finished laminated product, can be effected without dependance upon any of the company's other factories.

In response to the stimulus of a heavy volume of business, the Owens-Illinois Pacific Coast Co. of San Francisco has put its Decorating Department on a 24 hour basis

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MORE PLANT BETTERMENTS

The Pittsburgh Plate Glass Company, has announced an additional plant construction and modernizing program calling for an expenditure of $500,000. This, together with previous building expenditures authorized this year brings the total appropriation for plant improvement of the Pittsburgh Plate Glass Company to $5,080,000.

●

The Michel-Meier Company, Rochester, N. Y., will shortly reopen the plant at Rochester, Pa., formerly operated by the H. C. Fry Glass Company. The factory has been idle for quite some time.

●

The Lockport, N. Y., factory of Thatcher Manufacturing Co. shut down its furnace for repairs the middle of last month. Until these are completed, milk bottle production is being handled by the main plant at Elmira.

G. P. MacNichol, Jr., vice-president of the Libbey-Owens-Ford Glass Company, Toledo, has been elected a director of The Producers Council.

PUBLICATIONS

Properties of Refractory Materials Not Including Fireclays. S. M. Phelps. Technical Bulletin of the American Refractories Institute, Pittsburgh. Contains a table giving the more recent data pertaining to these materials and a chart of thermal conductivity values.

Chrome. Foote-Prints, Vol. 8, No. 1, P. I. A discussion of chromite, its occurrence in nature, method of preparation and applications, particularly in the steel and ceramic industries. Foote-Prints is issued semi-annually by the Foote Mineral Company of Philadelphia, and the article is written by Gordon H. Chambers, secretary of the company.

The New Density Comparator. Bausch & Lomb Optical Co., Rochester, N. Y. A bulletin describing a new instrument designed for accurate and rapid spectrographic analysis.

USE OF FELDSPAR IN THE GLASS INDUSTRY*

THE use of feldspar in the glass industry is rather recent. Indeed, feldspar has been used for a long time for the manufacture of opal glass and other opaque glasses, but its use for clear glasses has not been long known.

Long ago it was known that the Thuringian glasses had an excellent quality. No other glass could be worked so well before the lamp as the Thuringian tubes. Considerably later it was learned that the sand used in Thuringia contained a considerable portion of alumina. The quality of the Thuringian glasses was accordingly ascribed to the alumina. However, the aluminous sands mostly have a high and varying iron content which makes production of a good flint glass very difficult.

The author of this paper, even before the war, undertook research to introduce alumina into glass in other ways. Kaolin can be used for this purpose, as well as aluminum hydrate and aluminum salts. These materials, however, are either too expensive or melt with too much difficulty. He (the author) sought a means of introducing alumina into the glass which was cheap and convenient and came upon the use of feldspar. After prolonged research he has worked out a whole series of glasses with high and low alumina content. In this way a Hohenbockaer or Dorentruper sand could be used and it was now possible to melt a crystal-white glass with an alumina content which could be easily controlled.

It was now only a question of doing the industry the favor of introducing it to the use of feldspar because it made the glass considerably better. The greatest difficulty was finding a feldspar which was not only good but cheap and as uniform as possible in its composition, in order to forestall difficulties in the industrial application.

The introduction of the new material was very difficult in the conservative establishments of the industry. More and more, however, the glass industry has realized that science offers it a big advantage and the German glass industry has made especial progress in this respect in recent years.

And now concerning the use of the feldspar itself. The feldspar serves primarily to introduce alumina into the glass for the following reasons:

1. Alumina serves to lessen the tendency to devitrify, that is, a glass containing alumina will have much less tendency to devitrify in pots and in tanks than one free of alumina. When glass tubes become matt or rough before the lamp, it is nothing else but devitrification.

2. The chemical resistance of the glass is improved, that is, aluminous glasses are more resistant against solubility in water, weathering, etc.

3. Alumina lowers the softening temperatures, but increases the viscosity of the glass, that is, an aluminous glass has a greater working range, the temperature difference during working can be considerably greater than with an aluminous glass. An aluminous glass is "longer" than an alumina-free glass.

4. Aluminous glasses can carry a larger quantity of alkalies and lime than glasses without alumina. Nevertheless, the solubility (tendency to weather, dull, or become iridescent) is less.

5. Concerning alumina in general Dralle says, (p. 78-79) "By the addition of alumina the tendency to crystallization is retarded. The chemical resistance is increased, further it gives the glass very good mechanical properties. This has been proven in bottle glass. Especially resistant are green bottle glasses and this is almost entirely due to their high alumina content which in many bottle glasses ranges up to 15 per cent. A higher alumina content permits a greater lime content and it is well known that lime greatly lessens the attach of moisture on glass."

The fact that a higher lime content makes a glass more resistant to the action of moist air is, indeed, generally known; less well-known, however, is the fact that zinc oxide has a much better effect, and, again, still much better than zinc oxide is alumina. According to the work of C. J. Peddle[1] a glass with 10 per cent zinc oxide is 1.5 times as resistant as a glass with the same lime content, while a glass with 30 per cent zinc oxide is twice as resistant as the corresponding lime glass. A glass with the same alumina content, however, is 3½ times as resistant as a glass made from zinc oxide and equal to a boric acid glass.

The following ratio can be established:

SiO_2 %	Na_2O %	Al_2O_3 %	ZnO %	CaO %	Solubility ratio
70	20	10	..	..	1
70	20	..	10	..	3.5
70	20	..	..	10	5.25

From the table it is seen how great a protection an alumina content gives the glass against solubility.

The feldspar chiefly used in the glass industry has the following composition:

Loss of ignition	0.97%
Silica	69.40
Alumina	17.96
Iron oxide	0.05
Lime	1.05
Potash	10.00
Soda	0.55

The alumina in feldspar is not present as oxide, and consequently goes into the glass very easily, and as Dralle says in his new edition: "Feldspar is very well suited since it melts easily with the other glass constituents. Feldspar is also the cheapest material since it contains a high alkali content which means a distinct saving in the composition of the batch."

The melting point of the above mentioned feldspar is about 1250°. By itself it melts more easily than lime or sand. Furthermore, it may be mentioned that a glass melts more easily the more components used in its preparation. With the usual batch, only three components are present, silica, lime and soda. With the use of feldspar two more components enter, namely, alumina and potash.

Concerning the most favorable quantity which should be added to the glass, there are no valid scientific figures available. In a large glass factory tests on the following glass proved it to be almost incapable of being devitrified: (*Please turn the page*)

Silica	69.00%
Alumina	4.00
Lime	10.60
Soda	13.80
Potash	2.60
	100.00%

Such a glass can be made from approximately the following batch:

100 kg. sand
53 kg. feldspar
44 kg. soda
3 kg. sulfate
32 kg. lime

From numerous experiences, however, an alumina content of 2-3 per cent suffices to reduce the possibility of devitrification to such an extent, that in practical operation, even in large tanks, devitrification will not normally ensue. Such a glass can be melted from the following batch:

100 kg. sand
20 kg. feldspar
40 kg. soda
30 kg. lime

From this batch one obtains

112.9 kg. SiO_2
3.6 kg. Al_2O_3
16.7 kg. CaO
2.0 kg. K_2O
22.1 kg. Na_2O

157.3 kg. molten glass

The composition of this glass calculated from the batch would be therefore

71.7%	SiO_2
2.3	Al_2O_3
10.6	CaO
1.3	K_2O
14.1	Na_2O

This glass melts very well and is suitable not only for almost all hollow and pressed ware but also for window glass; it is adaptable to machine production, is cheap and extremely resistant to dulling. Glass made from this batch is strong and tough, may be ground and polished as well as mirrored. It is almost a universal glass for all possible purposes.

For the calculation on the use of feldspar the following must be noted: Feldspar contains, as noted above 17.96 per cent alumina, that is in 10 tons of feldspar there is contained 1796 kg. alumina and this corresponds to a quantity of 2800 kg. aluminum hydrate. The price of aluminum hydrate today is RM 25 per 100 kg.

Furthermore, the above mentioned feldspar contains 10 per cent potash which corresponds in a quantity of 10 tons to 1000 kg. potassium oxide corresponding to a quantity of 1540 kg. potash.

The feldspar also contains 0.53 per cent sodium oxide, which in 10 tons equals 53 kg. corresponding to a quantity of 84 kg. soda ash.

One buys, therefore, in a shipment of 10 tons feldspar of the above mentioned composition

6,940 kg. silica
2,800 kg. aluminum hydrate
155 kg. calcium carbonate
1,540 kg. potassium carbonate
84 kg. sodium carbonate

which is to be taken into consideration.

It is still to be noted that feldspar does not attack the refractories, hence aluminous glasses do not have the same avidity for the furnace walls as alumina-free glasses, since the rate of attack is lowered.

If one changes over to a feldspar batch, in a pot furnace, he can go directly to the new batch. However, care must be taken to use other cullet or, if old cullet from the other batch is used, to have it finely ground and thoroughly mixed.

Besides this, it must be well agitated, since the feldspar glass is somewhat tougher than the feldspar-free glass and it can become cordy by mixing with other cullet. Furthermore, care must be taken that the feldspar used is absolutely free of lumps. In the moist condition finely-ground feldspar is prone to form lumps. If these lumps are not completely broken up, they cause cords and even stones. Therefore, the feldspar must be thoroughly dry and lumps must be avoided. A mixing machine will take care of this. With hand mixing, the feldspar is best added through a sieve, whereby the lumps can be easily rubbed away. By observing these precautions no glass defects are to be feared.

Because of its somewhat greater viscosity, the refining of aluminous glasses in cold furnaces is somewhat more difficult. It proceeds satisfactorily, however, if a little salt cake of salt peter is added to the batch.

In tank operation the change over to feldspar is carried out by adding a small quantity of feldspar at first and best by replacing a small quantity of the sand with feldspar, gradually increasing this until the desired amount is reached. In tank operation, one must proceed from day to day or in large tanks from week to week or otherwise the glass will become cordy.

If glass is decolorized, the use of feldspar will require a trifle more decolorizer because feldspar contains a little more iron than good quartz sand.

The use of feldspar has proven so advantageous that no glasshouse should be without it.

*By Wilhelm Schmidt, *Glashütte*, 1934.
[1] "The Manufacture of Optical Glass". *Transactions of the Optical Society*, 23, 103, 1922.

GLASS DIVISION SUMMER MEETING

The Glass Division of the American Ceramic Society will hold its summer meeting this year at Lake Keuka, New York. Dr. J. T. Littleton has again offered the facilities of his summer camp, and will assume the role of managing host. Members will be housed in the camp cottages; and all meetings will be held in the Keuka hotel. The exact date has not been officially announced, but it is understood to be the closing days of the week ending September 14.

LIQUOR PROBE TO INVOLVE GLASSMEN

Glass manufacturing industries, manufacturers of glass package machinery, closure and sealing industries supplying materials to the liquor trade, are numbered among the pursuits marked for Congressional investigation in a bill submitted by Senator Lynn J. Frazier, of Hoople, N. Dak.

The Frazier Bill seeks to set up a joint committee of Congress "to study the legal and illegal practices established for the control of the liquor trade within the United States and its territories."

The committee would be empowered to subpoena witnesses and place them under oath to testify. Among those who would be subject to orders to appear before the committee would be Treasury Department attaches charged with enforcement of regulations for the packaging of liquors.

Quoting from the resolution: *"The Committee is authorized and directed to study the legal and illegal practices established for the control of the liquor trade within the United States and its territories; to study and investigate industries connected directly or indirectly in the servicing of the liquor trade, such as transportation, warehouses, glass-manufacturing industries, manufacturers of glass-package machinery, closure and sealing industries supplying materials to the liquor trade, printing industries supplying liquor labels and other similar industries, and paper and paper carton and package manufacturers; the use of patents for the establishing of monopolies for the control of the manufacturer of packages for liquor packaging; interlocking directorates and official control of the liquor industry and packaging industry; methods practiced for the evasion of taxes due the Federal Government on liquor sold; regulations promulgated by the Treasury Department for the control of liquor sales and packaging of same; and for the obtaining of liquor taxes due. The committee may report on its findings to the Congress at any time but shall report in full its findings before January* 10, 1936."

CATAPHOTE REFLECTOR BUTTONS

The Eastern Cataphote Company, New York, is the licensee under patents owned by the Libbey Glass Manufacturing Co., of Libbey Cataphote reflectors. It is a one-piece, button type optical glass lens, silvered on the rear, which reflects back light, as of an approaching car, and is visible at least 1000 feet from almost any angle. An interesting feature of the Cataphote design is that there is no space between the glass and the reflector, that might cause the reflector to tarnish. Instead, the "silver" is deposited directly upon the rear or objective lens and sealed by a special compound. When the buttons are arranged to spell words, they form a most effective night sign, requiring no upkeep or operating expense. Eastern Cataphote is trying to interest glass manufacturers in their use on buildings, etc., on the theory that the glass industry should use and advertise its own products.

AMSLER-MORTON CO. APPOINTS KARL W. GASS ITS CHIEF ENGINEER

Amsler-Morton Co. has announced the appointment of Mr. Karl W. Gass as Chief Engineer of the Company.

Mr. Gass was graduated from Cornell University in 1912, he spent the next four years with the United Pump & Power Company and with Chester & Fleming, consulting engineers. From 1916 to the present, he has been in intimate contact with the glass industry through a connection with the Fort Pitt Engineering Co., in the sale, design and construction of batch systems, and in the design of mechanical equipment of all kinds used in glass plants. Last year, the City of Pittsburgh placed him in charge of operating and handling all mechanical construction equipment and employed him as a consultant in preparing legislation for the control of mining operations in the city. Mr. Gass brings to his new position a wealth of experience and a background ideally fitted for the work he will undertake.

DISCOVERS HOW TO HARDEN COPPER ALLOYS

The rediscovery of a lost art—the hardening of copper alloys—was recently announced by the International Nickel Company. According to the engineers in charge, they have found that the addition of 3¾ per cent silicon to monel metal produces an extremely strong metal twice as hard as ordinary cast iron. Except for the characteristic silvery color of monel, this metal is said to resemble the famous hardened bronzes of the Romans, whose secret was lost in the intervening centuries.

William Beebe, deep-sea scientist, is reported to have abandoned quartz in favor of glass in his diving outfit. Recent developments in manufacture have made glass so strong that it will provide him full protection and better visibility, with a marked decrease in weight.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks ...Per 100 lb.		...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext. Per 100 lb.		...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	...	Po. or Gr. .25 / Cry. .25½
Alcohol, denatured, 50 gal. drum	gal.	...	.56½
Aluminum hydrate (A1 $(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.15
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	...	.10½
Antimony oxide (Sb_2O_3)	lb.	...	.12¾
Antimony sulphide (Sb_2S_3)	lb.	...	.11
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.049	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash		.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated ...In bags,	lb.	.022	.0245-.027
" (Dehydrated) ...In bags,	lb.	.0372½	.0455-.0502½
Powdered ...In bags,	lb.	.0245	.027-.0295
" (Dehydrated) ...In bags,	lb.	.04175	.0502½
Boric acid (H_3BO_3) granulated ...In bags,	lb.	.05	.0525-.055
Cadmium sulphide (CdS)—		...	.70-.75
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_2O_3) In bbls.	lb	...	1.25
In 10 lb. tins	lb.	...	1.35
Copper oxide Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.15
Black prepared	lb.	...	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08½	.09
Epsom salts ($MgSO_4$) (imported) technical Per 100 lb.		...	2.30
Feldspar— 20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%) Bulk, carloads, f. o. b. mines	ton	25.23	...
In bags	ton	26.83	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide— Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.065	...
In 5 Ton lots	lb.	...	.07
Less than 5 Tons	lb.	...	.075

		Carlots	Less Carlots
Lime— Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls. ...Per bbl.		2.25	2.25
Limestone ($CaCO_3$)	ton	1.75-2.50	...
Litharge (PbO) (New York Prices)	lb.	.055	...
In 5 Ton lots	lb.	...	.06
Less than 5 Tons	lb.	...	.065
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.03
Manganese, Black Oxide In Paper bags	ton	45.00	50.00
In Burlap bags	ton	46.50	51.50
In Casks	ton	48.00	53.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)— Crystals	lb.	...	.08½
Powdered	lb.	...	.09½
Potassium carbonate Calcined (K_2CO_3) 96-98%	lb.	.06⅞	.07⅛
Hydrated 80-85%	lb.	.06	.06¼-.06½
Potassium chromate (K_2CrO_4) 450 lb. bbls.	lb.	...	.16
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06½
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.17-.18
Rare earth hydrate 100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	...	Po. or Gr. .13½ / Cry.
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.) per oz.		...	.39
Soda ash (Na_2CO_3) dense, 58%— Bulk ...Flat Per 100 lb.		1.10	...
In barrels ...Per 100 lb.		1.50	...
In bags ...Per 100 lb.		1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.06½
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08
Sodium fluosilicate (Na_2SiF_6)	lb.	.04¼	.05¼
Sodium hydrate (NaOH) (caustic soda) Flake ...Per 100 lb.		3.00	...
Solid ...Per 100 lb.		2.60	...
Sodium nitrate ($NaNO_3$)— Refined (gran.) in bbls. ...Per 100 lb.		...	2.00-2.25
95% and 97% Bulk ... Per 100 lb.		1.175	...
200 lb bags ...		1.24	1.29
100 lb. bags ...		1.275	1.325
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50-1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)— Flowers, in bbls. ...Per 100 lb.		3.35	3.70-4.10
Flowers, in bags ...Per 100 lb.		3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls. ...Per 100 lb.		2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) in bbls.	lb.	...	.38½
Tin oxide (SnO_2) in bbls.	lb.	...	.54
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.00
Yellow orange	lb.	...	1.50
Zinc oxide (ZnO) American process, Bags	lb.	.0575	.06
White Seal, 150 lb. bbls.	lb.	.10½	.10⅞
Green Seal bags	lb.	.09½	.09½
Red Seal, bags	lb.	.08½	.08½
Zircon Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude, Gran. (Milled .005-.02c higher)		.03½	.04-.0

EQUIPMENT AND SUPPLIES

DRAKENFELD DISTRIBUTOR FOR JACK FROST ETCHING COMPOUND

B. F. Drakenfeld & Co., Inc. have recently been appointed distributors for Jack Frost which is one of the well known compounds used for frosting glass. Some of the outstanding features of this product are listed in a pamphlet being distributed by B. F. Drakenfeld & Co., Inc., a copy of which will be sent to those concerns who may be interested.

Some of the features pointed out in the pamphlet are that the material is furnished fully prepared in liquid form and ready to use; it is always chemically uniform; no special lead lined equipment is necessary and it may be stored and used in wooden tanks lined with sheet metal; it does not deteriorate; has no unpleasant odor; is safer to use than other compounds and reduces the hazard to the operator; it is economical and actual tests show that 1.4 pounds of Jack Frost will frost one gross of four ounce bottles, and that it produces a superior satin smooth finish which is both uniform and of fine texture.

JEFFREY VIBRATING HOPPER

The Jeffrey-Taylor Division of the Jeffrey Manufacturing Company, Columbus, O., announces a new type of electric vibrating feeder, designed for accurately controlling the feeding of chemicals, etc. It is claimed for this unit that it will insure a continuous, uniform flow of material. If desired, a vibrating hopper is supplied which will keep the entire feed column agitated as a live mass by transmitting the vibration through the feed material itself. Capacity without hopper, up to 7,500 lbs. per hour of silica sand; with hopper, up to 4,500 lbs. per hour.

PATERSON VIBRATORY SCREEN

The Paterson Engineering Co. (Arthur T. Ward, New York, distributor), has recently placed a new vibratory screen on the market. The screen consists of a vibrator element supported in an inverted U-shaped metal frame. Its two most interesting features are its ability to adjust the vibration to suit the material, and a simple method of holding screen cloths to permit of quick replacement.

NEW GRINDING TOOL

The Chicago .Wheel and Manufacturing Company, Chicago, Ill., has just placed on the market an interesting new grinding tool, illustrated here. It is furnished with complete accessories which permit one to grind, drill, polish, cut, carve, sand, saw or engrave. In the ceramic industries, it is particularly useful for removing blemishes, grinding molds, etc. The Hand-ee Grinder, as it is named, weighs only 12 ounces and has a speed of 25,000 r.p.m.

CATALOGS RECEIVED

The Why and How of Bronze Powder. The O. Hommel Co., Pittsburgh. A brief historical sketch of the development of bronze powder that leads into methods of its application, different qualities of the powder, information as to shades or colors, volume, etc. A great deal of information of value to the user is presented in a most interesting manner.

Efficient Regulation of an Air-Conditioning System. Leeds & Northrup Company, Philadelphia. A 24 page pamphlet, illustrated with photographs and diagrams, explaining to the owner, architect, engineer and contractor, what each needs to know about electrical thermometers.

This New Industrial Pick Up. The Elwell Parker Electric Co., Cleveland. An ambitious brochure of 32 pages and more than 50 operating illustrations, explaining the new pallet system for materials handling. The pallet system is represented as being more economical than the skid method now used in practically all glass plants.

Modern Box Design. The Hinde & Dauch Paper Co., Sandusky, O. The design of corrugated fibre shipping box exteriors, and the technique involved, is discussed in a new and unusual manner. Manufacturers so wishing can secure copies containing illustrations of special interest to them if they indicate the nature of their business when writing.

G-E Pyranol Capacitors. General Electric Company, Schenectady, N. Y. Describing apparatus for improving the power factor in industrial plants by neutralizing the effects of magnetizing current. 28 pages. Illustrated. Tables, diagrams, charts.

Draft Gage Catalog PGA-35. The Hays Corporation, Michigan City, Ind. 24 pages with illustrations covering the company's complete line of Dry Type Pointer Draft Gages. Inclined Tube, Direct Reading, U-Tube and Vernier Scale Gages, and Dry Type Draft Recorders.

Motors for Centrifugals. The Louis Allis Co., Milwaukee. A four-page pamphlet dealing with the special characteristics and containing information about the electric motors built by this company for centrifugals. Ask for Bulletin 601.

BORAX PRICES UP

American Potash & Chemical Corporation has announced an increase in the price of borax and boric acid; the former advancing $4.00 the ton and acid $15.00. This is the first price advance made by this company in a number of years, the last one being to reduce borax in bags from $47 to $38, the lowest price level in its history. Now, increased freight rates, labor costs and all items in the manufacturing process have affected production costs to such an extent as to make it impossible to absorb these items any longer, say the manufacturers.

HEATING UP A GLASS TANK FURNACE

(*Continued from page* 213)

attributed to a change of wind direction which occurred at about the same time. Investigation disclosed that the quality of the gas changed. In another case in a factory located in a valley, it was found that a shift in wind direction was a cause of difficulty and that when conditions were corrected to get uniform air pressure, the furnace operated normally. Furnaces at the end of the line or shielded by buildings and other obstructions may not operate normally but the reason can generally be located.

Because of changing climatic and atmospheric conditions, it is difficult to lay down a rigid schedule to follow in heating up or operating a furnace. In heating a tank furnace, the pyrometer equipment is only one of the tools which can be used as a guide. The combined use of several guides such as length of flame, fuel consumption, and rate of expansion of refractories seem desirable.

Mr. Wright brought up the question of cracking of tank blocks during the heating up. His observations are that blocks that have an average expansion greater than 0.3 per cent up to 200°C crack easily in the heating up regardless of the schedule. There are other influences, such as pressure caused by binding which will also cause cracking. He believes that this expansion at lower temperatures is more important than the one at the quartz inversion temperature of 573°C.

Mr. Oakley, of the Corning Glass Works, expressed the opinion that much of the cracking of blocks was due to the treatment they had received in the drying and burning process.

Mr. Linder, of the Pittsburgh Plate Glass Company, stated that a high silica block best serves the purpose of production of high quality glass. This type of block is apt to crack with fast heating. Using a 19-day schedule, no cracks were found and a wonderful length of life resulted. The use of a long heating period does does not appeal to the user of tank blocks.

Dr. Uhrmann, Peltier Glass Company, said that his experience was confined to small tanks, but that it had been found advantageous to protect the outside of the blocks as much as possible. He had found that the protection of the outside walls by use of cardboard was an aid in getting even heating. The cracking of blocks in the heating process can easily reduce tank life by 30 per cent.

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BOOK REVIEW

"*Lehrbuch der Glastechnik*" (Textbook of Glass Technology). By Dr. Ludwig Springer, Zwiesel. Published by "*Die Glasshutte*", Dresden. 145 Pages, 65 Illustrations.

This little book is intended as an introduction to the subject for the use of students in the technical school for the glass industry and hence has been held down to extreme brevity. The introduction consists of a list of important dates in the history of glass technology, bringing in the great names and achievements of technologists and inventors.

There is no attempt at detailed description of glass compositions and the chapter on properties is likewise very brief, consisting of scarcely more than outline. Under raw materials, sand, lime, soda, salt cake and potash are described at some length and others barely mentioned as to coloring or refining effect.

The outstanding feature of the book is its wealth of pictures and diagrams, covering everything from the glass furnaces shown by Agricola to the most modern piece of glassworking machinery. A good deal of attention is paid to the development of producers and firing systems and furnace designing. In these matters, the publishers have drawn heavily upon the illustrations from Dralle-Keppeler's well known work. Clever diagrams explain such matters as physical decolorizing and the classical explanation of strain. The main body of the book is taken up with the description of glassworking processes. In this chapter, after the student has had brief directions about mixing of batch and the calculation of batches and compositions, he is introduced to methods of handworking, set forth by careful description and excellent illustrations. Then the development of machines of all sorts occupies practically the remaining half of the book. There is a chapter on decorative processes and the book closes with a brief description of the government school for the glass industry at Zwiesel in Bavaria.

While this book adds nothing new to the literature of the glass industry, it is an example of what can be done to make an elementary textbook, in a highly technical subject, attractive and genuinely interesting to the beginning student. The book is to be recommended to any who have even a slight reading knowledge of German for the sake of its illustrations and the insight it gives into German methods of glassmaking. S. R. S.

DIAMOND MODERNIZATION PROGRAM CONTINUES

On June 1, the Diamond Glass Company, Royersford, Pa., completed the first part of its reconstruction program which was begun last January. This has included the installation of modern batch handling equipment, feeders and lehrs. Many notable reductions in cost have been achieved directly attributable to the use of modern equipment and the results have fully justified the plans formulated by the management. This month the second half of the program will be instituted, which includes complete modernization of all equipment, processes and methods designed to provide maximum flexibility in meeting shipments coupled with a high standard of quality.

DRAKENFELD ANNOUNCES

Jack Frost

AN EFFICIENT FROSTING COMPOUND

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2. Chemically uniform. You can always depend upon every lot being just like the last one. Removes all uncertainty from results.

3. It will not deteriorate. Good till the last drop.

4. Economical. No special equipment needed. No time consumed in mixing or other forms of preparation. No waste—use it until gone. Tests show 1.4 lbs. will frost 1 gross of 4-ounce bottles.

5. Convenient. Comes to you as a liquid in ready-to-use form. Just open the container and go to work.

6. It is safer to use than other compounds and reduces the hazard to the operator.

7. Odorless. Does away with exhaust equipment provided ventilation is normal.

8. No special lead tanks needed. Many glass manufacturers use ordinary wood tanks lined with sheet metal, both for storage and for the etching bath.

9. Permanent results. It actually etches the glass and the finish cannot be removed.

10. Backed by Drakenfeld — 65 years of service to the glass industry.

Send for folder describing method of using Jack Frost and other detailed information.

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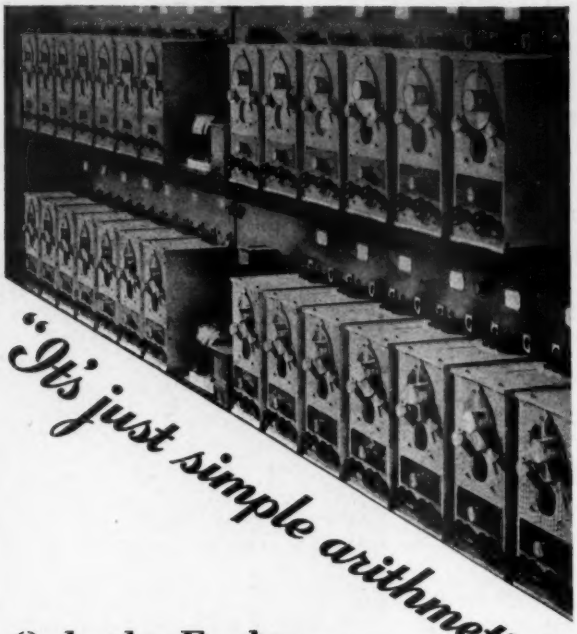

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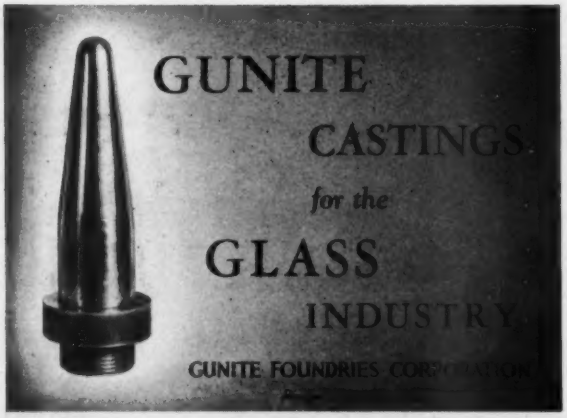

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